The Blast Furnace and Steel Plant

Managing Editor: ELMER C. COOK

Engineering Editor: FRED J. CROLIUS

EDITORIAL ADVISORY BOARD:

W. TRINKS
THEODORE S. SEE
DR. J. S. UNGER
BARTON R. SHOVER
FRED CRABTREE
E. H. McCLELLAND
KENNETH B. LEWIS
F. E. KLING
DONALD N. WATKINS

CONTENTS

VOL. X **NOVEMBER, 1922** **No. 11**

Page

AMERICAN IRON AND STEEL INSTITUTE MEETING 541

PRESENT STATUS OF THE ELECTRIC FURNACE—By John A. Mathews 542

THE STEEL REQUIREMENTS OF THE AUTOMOTIVE INDUSTRY—By Henry Chandler .. 544

USE OF LIQUID FUEL IN METALLURGICAL FURNACES—By R. C. Helm 549

HEATING FURNACES FOR BLOOMS, SLABS AND BILLETS—By W. P. Chandler, Jr. 556

FLUORSPAR AND ITS USES—By G. H. Jones 563

BASES OF MODERN BLAST FURNACE PRACTICE—By A. K. Reese, Part II 568

BOOK REVIEW 574

BY-PRODUCT COKING WITH PARTICULAR REFERENCE TO NEW COMBINATION OVEN—By Joseph Becker 575

DISCUSSION OF HEAT BALANCE—By J. B. Crane 583

THE ECONOMIC IMPORTANCE OF THE POWER PLANT IN THE STEEL INDUSTRY—By E. F. Entwisle 585

UNDERFEED STOKERS BURN LOW GRADE OF COAL—By C. E. Reese 588

CORROSION CONTROL BY DEACTIVATION OF WATER—By Frank N. Speller, Part II ... 592

THE OPEN HEARTH 598-599

NEWS OF THE PLANTS 600

SOME POINTERS ON BY-PRODUCT COKE OVEN OPERATIONS 601

WITH THE EQUIPMENT MANUFACTURERS 602-603

TRADE PUBLICATIONS, TRADE NOTES 604

Published the first of each month by The Andresen Company Inc.

Main Office—Thaw Building, 108 Smithfield Street, Pittsburgh, Pa.

President: F. C. ANDRESEN **Vice President:** L. L. CARSON **Secretary and Treasurer:** N. G. EYSTER

Branch Managers

ROBERT E. POWELL, Eastern Mgr.
47 West Thrity-fourth Street
New York, N. Y.

JOHN L. COBB, Western Manager
1635 Lytton Building
Chicago, Ill.

BURNHAM FINNEY
501 Union Central Building
Cincinnati, Ohio

Subscription Price:—In the United States, $2 per year; Canada, $2.50; all other countries, 3.50. Single Copy, 25 cents. Entered as second-class mail matter at Pittsburgh, Pa., under the Act of Congress, March 3, 1879.

Generated on 2024-09-08 15:49 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

Digitized by Google

Original from UNIVERSITY OF CHICAGO

The Blast Furnace and Steel Plant

Vol. X PITTSBURGH, PA., NOVEMBER, 1922 No. 11

American Iron and Steel Institute Meeting

Judge Gary Suggests Second Washington Peace Conference at Twenty-Second General Meeting—A Number of Extremely Valuable Technical Papers Were Read.

ON October 27 the American Iron and Steel Institute held its twenty-second semi-annual meeting in New York. The day was devoted to the address of the president of the Institute, Judge Elbert A. Gary, chairman of the United States Steel Corporation, and to the reading and discussion of technical papers, which are listed below. A number of these papers are included in this issue.

Address of the President, Elbert H. Gary, chairman, United States Steel Corporation, New York.

"Modern Methods of Mining Coal," H. Foster Bain, Director, Bureau of Mines, Washington, D. C.

"The Storage of Bituminous Coal," H. H. Stoek, Professor of Mining Engineering, University of Illinois, Urbana, Ill. J. V. Freeman, Director, Coal and Coke Research Laboratory, United States Steel Corporation, Joliet, Ill.

"The Present Status of the Electric Furnace in Refining Iron and Steel," J. A. Mathews, President, Crucible Steel Company of America.

"Economic Importance of the Power Plant in the Steel Industry," E. F. Entwisle, Assistant General Manager, Steel Plant, Bethlehem Steel Corporation, Steelton, Pa.

"The Steel Requirements of the Automotive Industry," Henry Chandler, Metallurgist, C. H. Wills & Company, Marysville, Mich.

"Heating Furnaces for Blooms, Slabs and Billets," W. P. Chandler, Jr., Fuel and Experimental Engineer, Carnegie Steel Company, Duquesne, Pa.

"Use of Liquid Fuel in Metallurgical Furnaces," R. C. Helm, Director, Worcester Research Laboratory of the American Steel & Wire Company, Worcester, Mass.

"The Thermal Efficiency of the Open Hearth Furnace," C. L. Kinney, Jr., Superintendent No. 1 Hearth Department, South Chicago Works, Illinois Steel Company, South Chicago, Il. G. R. McDermott, Fuel Engineer, South Chicago Works, Illinois Steel Company, South Chicago, Ill.

"Fluor Spar and Its Uses," G. H. Jones, President, Hillside Fluor Spar Mines, Chicago, Ill.

Gary Suggests Nations' Meet.

Another international peace conference in Washington for the full and frank discussion of all unsettled financial, commercial and industrial questions in which the United States is interested, was suggested by Elbert H. Gary, chairman of the United States Steel Corporation in a speech at the semi-annual meeting of the American Iron and Steel Institute, of which he is president. Such a conference, he said, should be participated in by able, open-minded, well-disposed representatives from the different nations, such as those who appeared at the recent limitation of armament conference.

"If there be such a meeting," he declared, "and the delegates are all of the type referred to, there will result incalculable good to all who are parties. They would not decide how to overcome the old established law of supply and demand, how to avoid or repudiate existing obligations, but rather how and when to fulfill them without irreparable injury to anyone or the sacrifice of principle. While it is true members of such a conference would be compelled to consider and in a large measure be governed by the wishes of their respective constituencies, it is believed the large majority of the populations making up such constituencies would be sensible and honest."

Should Pay War Debts.

Cancellation of Europe's war debts to the United States was opposed by the speaker. The debts, he said, were voluntarily, openly and fairly contracted and cannot be cancelled or disposed of on any other basis, without doing damage to justice and rules of propriety.

"To cancel these debts or any part of them without full payment," he asserted, "would be forced charity, and that is never agreeable to the donor, and, as a rule, equally disagreeable to a self-respecting person or nation. It is the individual citizens of the different countries who are to be consulted and whose decisions must control.

"Americans generally would not be content with governmental action which relieved from debt the citizens of a foreign nation by increasing the burdens of the former. Likewise foreigners generally would oppose any enforced act of charity. Certainly it would be abhorrent to the business man and woman of both countries."

Generated on 2024-09-08 15:49 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

The attitude and conduct of a nation, he said, should not be different from that of an individual.

Thinks Nations Can Pay.

"In the judgment of many of us the foreign nations can and are willing to pay their debts, some sooner than others, and most of them sooner than is now generally admitted. We know something of their capacity to work and earn and save and their successes in business and their mode of living. No doubt in many instances productive capacity has been reduced and we share in their suffering on account of deprivation.

"We should be cheerfully willing to extend payment at reasonably low rates of interest. We should be glad to make new loans whenever we are confident they will be paid, and thus assist in restoration and rehabilitation. Every man or nation, in order to measure up to obligations, must work and save, must be prudent and economical."

Settlement on both sides of industrial disputes or questions involving the welfare of the pubic was advocated by the speaker.

There are no obstacles to continued prosperity in the iron and steel business in the United States, the speaker asserted, except such as may arise from interference with the natural course of supply and demand. Touching on the recent coal and rail strikes, he said if the natural course of business had not been interfered with the iron and steel industry would now be enjoying success and prosperity greater than ever before, so far as volume is concerned. The one to blame, he said, is "any one who by word or deed has interrupted or hindered the operation of the natural laws of supply and demand; or has interfered with the full, free and unlimited right to work, to operate, and to produce."

*Present Status of the Electric Furnace**

Brief History of Development of Electric Furnace for Refining Iron and Steel—Reasons for Expansion of Electric Steel Making —Demand for Clean, Sound Steel Will Cause Its Increased Use.

By JOHN A. MATHEWS†

IT seems to have been generally overlooked by the steel trade that this year, 1922, marks the ter-centenary of iron making in the Western Hemisphere. In 1622, the first iron was made at Falling Creek, Va., and in the same year the plant was destroyed and the workmen massacred by the Indians. It is a far cry from charcoal hearths and forges to the consideration of the electric furnace—the latest development in steel making processes.

The earliest literature of electric melting of iron and steel dates back but a score of years and was provided by the inventors of various furnace types. It is characterized by the enthusiastic optimism of the inventor and on that account may not have been considered very seriously by conservative, practical steel men. Their confidence in electric furnaces may not have been greatly increased during the next few years by the writings (including my own) of those who made the earliest installations. They may have felt that there was something of the child-with-a-new-toy air about them, and that both inventors and early users were overstating the case and that time and further experience might change matters. The war needs stirred some of the doubting Thomases to action and furnaces were installed in great numbers, particularly in the years 1917 and 1918. So rapid was the introduction of electric furnaces at this time that I felt constrained to utter a word of caution in a previous paper to this Institute‡ when I said: "We will pass through a period of reaction and dissatisfaction with electric products while many of the new furnaces are in the experimental stage."

This opinion was based upon the fear that furnaces could be built faster than skilled operators could be trained. I now feel that my fears were justified by the experiences of the war period, for much electric furnace product was not what it should have been, and possibly not as good as much of the open hearth product produced during the same period. I have always discouraged the idea that the electric furnace was a foolproof and automatic process for making superior steel by those unskilled in steel making.

I believe now that the period of disaffection is past and that the 16 years of experience, since the first electric furnace was installed in America, at the Halcomb Steel Company, have been sufficient to afford a sounder basis of judgment than may have been afforded by the earlier literature already mentioned. There are now nearly 1,000 electric furnaces in America and Europe, not quite one-half of them in the United States and Canada. Constant interest in these developments from the beginning leads me to feel that the pioneer writers were not over enthusiastic and that their claims and predictions have, in general, been fulfilled.

It will surprise many of you to know that Italy has about 180 electric furnaces for steel melting, that 27 of them are from 15 to 25 tons capacity, and in 1921 her tonnage of electric steel was second only to that of the United States, and reached a new high mark for that country. The annual productive capacity there is about 1,000,000 tons, and Doctor Giolitti recently told me that some of these furnaces were operating at unusually high speed and with great economy of electrode consumption, as low as 6½ pounds per ton for cold melting. For installed capacity, Italy ranks ahead of Germany, England

*A paper read before the American Iron and Steel Institute, at New York, October 27, 1922. The paper was entitled, "The Present Status of the Electric Furnace in Refining Iron and Steel."

†President, Crucible Steel Company of America, New York.

‡"The Electric Furnace in Steel Manufacture," Yearbook, American Iron and Steel Institute, 1916, p. 73 (May, 1916).

Generated on 2024-09-08 15:48 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

and France, and second only to the United States.

The rapidity with which electric furnaces have been installed within the last decade all over the world calls for some analysis as to cause. After 10 or 12 years of invention and pioneering there were about 125 furnaces in the world in 1912. At this time, Germany led with nearly one-third of the total number. Today, as nearly as may be estimated, there are 1,000 furnaces, 388 of them being in the United States, according to the *Iron Age* figures for January 1, 1922. Accurate statistics have been extremely difficult to secure during late years, but according to Doctor Richard Amberg* there are 65 furnaces in Germany engaged in the manufacture of ingots, with a yearly productive capacity of 430,000 tons and an unknown number of furnaces making steel castings with a capacity estimated at 300,000 tons per annum. I think we may estimate the total number of electric furnaces in Germany as about 100 to 110.

The reasons for the world-wide expansion of electric steel making are three:

(1) Cheapening of wholesale power rates, due to hydro-electric and improved steam plant developments. Thus it is now commercial to use electricity for melting, whereas the original promoters of arc furnaces felt that their use would be of necessity confined to refining of metal premelted by the older processes.

(2) The extreme flexibility and adaptability of electric furnaces to a wide range of uses. It has been shown by experience that they may be successfully used for melting cold charges or refining liquid charges, for making ingots or castings, and for melting ferro-alloys. They may be used in conjunction with the blast furnace or cupola for making grey-iron, malleable and semi-steel castings. For foundry use particularly, the small units are advantageous for making frequent small heats of steel or iron castings.

The most popular size of electric furnace in this country is of six gross tons capacity, but furnaces from one-half ton to 40 tons capacity have proven equally successful. In furnaces of six tons, or a little larger, hand charging is general, but in the larger sizes either mechanical charging of cold materials or the use of hot metal charges is usual. Duplexing of open hearth steel is practiced in many of the larger units, while triplexing is done at the great installation at the Illinois Steel Company as described at the Institute a few years ago by Mr. T. W. Robinson†.

All of the manifold methods of operation are possible with the use of arc furnaces, which are by far the most frequently used, here and abroad. Of the different types of arc furnaces in the United States nearly one-half are of the Heroult type and considerably more than one-half of the productive capacity is represented by them.

The electric furnace has small possibilities in this country for the manufacture of pig iron from the ore, but during the war period several furnaces were used to make so-called synthetic pig iron from turnings and borings and other light scrap, in the United States, Canada and France. In Sweden, Norway and Italy, where metallurgical fuel is very dear and electricity is cheap, electric smelting of ores is an established industry. The world's production for 1921 is placed at 377,900 tons, and most of you will recall that the year 1921 was not a good year for high records.

*Electric Furnaces in the Iron and Steel Industry, Helios, vol. 28, p. 169, for April, 1922.

†"The Triplex Process of Producing Electric Steel at South Chicago," Yearbook, American Iron and Steel Institute, 1918, p. 115.

(3) Quality of products. A new process to succeed must be cheaper in operation or produce a better quality. The cost of electric steel is rarely lower than open hearth and never lower than Bessemer and therefore its success is presumably due to its producing a generally superior product. Of course, there are especially favored localities or peculiar market conditions which warrant the installation of small electric furnaces where open hearth and Bessemer installations would be out of the question. In the same localities and markets electric furnaces do operate successfully alongside of large tonnage plants and under such conditions quality must be the principal reason for success rather than low cost.

It is quite obvious that this country has not installed 1,500,000 tons of productive capacity to compete with the present crucible capacity of one-tenth that volume. In an address several years ago, I said, "It is seldom that a process is discovered that cannot be improved upon. Crucible steel is an exception to this rule. This earliest process makes the best steel and has never been surpassed." The superior lasting qualities of German guns was often ascribed to the use of molybdenum, zirconium, uranium or other strange alloys, but my own idea is that the use of clean, well melted crucible or electric steel is a more probable explanation. Crucible steel was employed for many submarine crankshafts, and apparently the Germans recognize that when fabricating and machining costs are far in excess of material cost, and where dependability is a vital necessity, it is a poor policy to save at the spigot and let out at the bunghole. Quality depends upon the selection of raw materials, the process of melting and subsequent care in forging and heat treating. The electric furnace provides a reducing atmosphere in which sulphur is readily removed and with it goes one of the generally recognized inclusions, manganese sulphide, and the same condition serves to eliminate oxides.

The electric furnace, therefore, is a potential source of clean steel which is more highly appreciated than formerly, and the electric product is opportune to meet the new and exacting requirements for ordnance, automobiles and aeroplanes, and other devices in which alternating stresses are very severe. The importance of clean steel has been observed in the course of extensive investigations of the fatigue of metals under the direction of Professor H. F. Moore. It is not too much to expect that the higher the elastic or proportional limit resulting from heat treatment, the more serious would become defects such as non-metallic inclusions and seams in parts made from inferior steel. Doctor McCrance confirms this in stating that fatigue failure under repeated stress is a progressive failure, starting in all cases in some defect or irregularity either of internal structure or external surface.

By way of illustrating the freedom from inclusions in electric steel, I might mention the result of actual count of hairlines, due to inclusions, in the ground surface of steels of the same chemical specification—a chrome-nickel steel for aeroplane crankshafts. As the result of tests on several heats of this steel by the basic, and acid open hearth and basic electric process, the average count ran in the ratio of 8 to 4 to 1, and the hairlines in the electric steel were much shorter than in the steel of open hearth manufacture. Another illustration from my own experience may be convincing. In one of the races at the Indianapolis Speedway a few years ago, about one-half of the cars starting did not finish because of failure of vital parts. The following year nine or ten cars, which

Generated on 2024-09-08 16:14 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

I knew contained our electric furnace product in their important parts, all finished the race without mishap, and included the winning car. A practical demonstration of this kind is more eloquent than columns of figures of laboratory tests. The recent paper by W. J. Priestley* outlines the splendid results of electric furnace ordnance steels made at Charleston, W. Va., in the largest furnaces in the United States. He shows that the results are due to clean steel and freedom from oxides, sulphur and phosphorus. These results show that large units, with proper handling, can produce very high quality steel, and we see no reason, now that larger electrodes can be made of dependable quality, why a 60 or 80-ton furnace cannot be expected to give relatively as satisfactory results. The electric steel rail is still a desired possibility. The increased demands made upon materials of construction call for new methods for meeting those demands. As I stated here six years ago, the electric furnace was opportunely invented to meet a new demand rather than to replace an old process.

It would be mere repetition to restate here the various types of furnaces, such as arc, induction, radiation, etc. They have been described in books and technical magazines and we need only observe in passing that there have been no new principles of heating employed since the first few years—with the possible exception of Doctor Northrup's high frequency induction furnace which has not thus far been successfully employed in units of commercial size in the steel industry. Of mechanical and electrical refinements there have been many, all in the nature of improvements in regulation and economy. Among these may be mentioned two of American origin, J. A. Seede's automatic electrode regulator, and E. T. Moore's peak-load regulator. The principle of dual, or rather multiple, voltages was embodied in our orginial installation in 1906, but its metallurgical significance was not so apparent as it was later when we installed a process employing a 220-volt arc and with considerable difficulty succeeded in persuading the inventor that provision for a lower voltage for use during the refining period must be provided. The desirability of relatively high voltage for melting and low voltage for refining is now generally recognized. Many improvements have been made as the shortcomings of the earlier furnaces appeared, such as well fitting doors, water cooled arches, better electrodes and holders and economizers to cut down oxidation and waste of the electrode. In my own experience I have seen electrode costs per ton of product as high as $8.00 gradually decline to 35 cents. This was in a furnace refining molten charges.

The electric furnace is also a recognized factor in melting non-ferrous alloys such as "Nichrome," "Rezistal," "Stellite," stainless steel, manganese steel and high-speed steels, besides an endless variety of the simpler alloy and carbon steels from the mildest to the hardest tempers. As stated earlier in this paper, its astonishing flexibility—versatility, we might call it—has attracted the attention of the metallurgical world in almost every branch of smelting, melting, refining, heating and even baking metals. To those of us who have watched its growth from the start, it seemed very slow in achieving the recognition we felt must inevitably come to it, but at last our early confidence has been confirmed in every steel-making country, because its products have fulfilled almost every expectation in every field wherein it has been thoroughly tried. The present success is due not only to the original inventors of the basic processes, but also to the active co-operation of the great manufacturers of electrical equipment, furnace designers and builders, makers of refractories and electrodes and a group of earnest metallurgists in many individual plants who have studied every detail of operation.

When users acquire a full appreciation of what clean, sound steel means in terms of national efficiency, safety and economy we shall see more rapid growth that has as yet been seen. Its usefulness to engineering and industry has just begun.

*"Effect of Sulphur and Oxides in Ordnance Steel," Transactions American Institute of Mining and Metallurgical Engineers, vol. lxvii, p. 317 (1922).

The Steel Requirements of the Automotive Industry*

Steels Suited to Process of Fabrication, Service Conditions and Major Automotive Parts—Tests to Determine Mechanical Properties—Reduction in Area an Indication of Qualitative Importance

By HENRY CHANDLER†

PRIMARILY, the physical properties of automotive steels determine which of those steels are best adapted and most essential to the automotive industry. Speaking generally, the mechanical characteristics of materials determine, first, the thing we are able to make, and second, the methods we are to employ in making it. The discovery of each new material is invariably followed quickly by the development of many new devices to adapt this new material to man's use. Conversely, the removal from the market of any of our common materials, such as copper or rubber, would result in a far-reaching industrial readjustment.

The more highly specialized an industry becomes in its development, the greater is that industry's dependence upon the properties of the metals peculiar to it. Our first thoughts in the development of a

*Paper read before the American Iron and Steel Institute, at New York, October 27, 1922.

†Metallurgist, C. H. Wills & Company, Marysville, Mich.

Generated on 2024-09-08 15:55 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

mechanical idea are governed by and limited to the materials then available. Later, competition and a fuller understanding of our actual needs result in the discovery of materials still more suitable. For instance, in the early pioneer days of the motor car industry, crankshafts were made from billets intended for rails, gears from tool steel, cylinders from iron suitable for stoves, and, similarly, all other parts were made of the only materials then available.

Such practice would now be not only impractical, but actually impossible. Today we rely upon specialized automotive steels for our major parts. The automotive manufacturer is now buying physical properties. The chemical specifications, from which steels are actually purchased, are not of importance in themselves but only for the physical characteristics which they define. It is the mechanical characteristics of the steels that are of prime importance to the manufacturer, both in the design of his product and in the mechanical methods he is to employ in manufacturing it. These are the two factors that determine his commercial success.

It will be necessary in this report to generalize. It is manifestly impossible to treat the numerous parts of a motor car individually. The steels now used by the automotive industry, their treatment and characteristics, can be found amply described in the specifications of the Society of Automotive Engineers and other organizations. Detailed application of these specifications to a given part or group of parts is impractical without a thorough knowledge of the conditions demanded and can be of only individual interest. We will, therefore, only attempt to determine which of the many steels now used by the automobile builder are characteristically "automotive steels" and the general properties such steels must possess, in terms of the tests usually applied to them.

The adoption of a steel for commercial purposes is predicted upon two general questions; first, "How will this steel adapt itself to the necessary manufacturing processes?" and second, "Will the part, when made of this steel, withstand the forces, such as wear, breakage, etc., that operate for its destruction?" The answer to these questions is obtained through a survey of the mechanical characteristics of the metal. This twofold importance of the physical properties suggests a natural division of the various parts of motor cars.

Steels Suited to Process of Fabrication.

Our first group will contain all those automotive parts which are made from steels in which the physical properties, that control the processes of fabrication, are of first importance.

This group includes most of our sheet metal parts, low stressed bolts, nuts and other screw machine products, as well as miscellaneous forgings, hardware and stampings. Such parts, due to design, when made from almost any material which will commercially meet the manufacturing requirements, are amply strong and tough to withstand all normal service conditions. Our specifications for this group are directed to simplify fabrication.

These requirements are easily and quickly ascertained. As a matter of fact, actual use becomes the best criterion and we are able to define our steels in terms of how they must behave in the shop. Our deep-drawing stock must draw deeply. Our screw machine stock must machine readily. Our forging bars must be free from defects and respond readily to forge and machine shop operations. Uniformity of quality is as important as degree of quality.

In general, requirements of this nature are not peculiar to the automotive industry. They are common to all industries where steel is similarly fabricated and such steels are "automotive steels" for the single reason that large quantities of them are consumed by the automotive industry.

In particular cases, however, the manufacture of certain individual parts of this group has been developed into separate specialized industries and we here find a corresponding development of individual steels of this class into special steels. This has been the case particularly with frames, fenders, cold-headed bolts, disc wheels, bodies, etc. Each of these presents its individual problems and each requires its individual steel specifications, specialized proportionally to the refinements in manufacture and design which have been developed by the individual manufacturer.

Chemically expressed, the needs of this group are amply met by the standard grades of carbon steels now manufactured.

Steels Suitable for Service Conditions.

The second group contains those special automotive parts which are made from steels in which the physical properties demanded by service conditions are unusual and of first importance. Steels for such parts, due to the peculiar conditions of service to which they are subjected, must have individual physical properties developed to an unusual degree. The mere ease of manufacture is of secondary importance and is considered only after the service requirements are amply met. Valves, ball bearings, magnets, armatures, hardened keys and the like are all typical of this class.

For example, in valves, strength, hardness and toughness must be maintained at high temperatures and the metal must withstand the corrosive and erosive effects of the products of combustion. To meet these particular requirements, many special steels have been developed, such as high-tungsten, silicon-chromium, cobalt-chromium and others, each with its own peculiar advantages for this service, and each with its own distinct engineering following. It was only after long, intensive development of materials that ball bearings became possible for motor car use. Also the electrical properties now attained in armature and magnet steels are evidence of the specialized nature of these parts.

Naturally, then, this group requires special analyses. The manufacture of these parts or of the steels suitable for them can be commercially undertaken only after a thorough understanding of the complex problems involved. Adequate treatment of this specialized group is manifestly not within the scope of this paper.

Steel for Major Automotive Parts.

The third group, and that one with which we are chiefly concerned, contains most of our major steel parts. The front axle and its various component units; our power train from piston pin, through connecting rods, crankshaft, transmission, universal joint, to the rear axles; springs; heavy duty gears; and, in general, all parts subjected to live loads of a high order are included in this division.

These parts are uniquely automotive parts, that is, the forces of wear, fatigue and breakage to which they are subjected; the processes by which they are fabricated; and the economic factors which limit their cost,

Generated on 2024-09-08 15:49 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

are peculiar to and characteristic of the automotive industry alone.

The steels for these particular parts may, therefore, be truly called "automotive steels." Their development into the many standard grades of alloy steels has been coincident with and in a large measure responsible for the development of the motor car.

Parts in this group, in operation, are subjected to much punishment. Wear, shock, vibration, torsion and other complex application of forces all tend to destroy their usefulness. Our steels must resist all these and at the same time readily and economically adapt themselves to the numerous processes of forging, heat treatment and machining, incidental to the production of these parts. The quality of our part cannot be separated from the cost of our part.

Tests Used to Determine Mechanical Properties.

How then are the mechanical characteristics necessary to fulfill these conditions determined?

The automotive manufacturer relies upon two types of test; first, that of actual use itself, and second, comparatively simple and rapid laboratory tests, whose indications he has learned to correlate with the results of actual use.

The test of actual use, while undoubtedly our final criterion, nevertheless has serious disadvantages. It is generally slow and its results are difficult to express in terms usable in steel specifications. We cannot, for instance, describe our steel to the producer by stating that it must be the best and cheapest for our crankshafts, gears or other parts. We must have a means of measuring these requirements; some common method of defining the degree of hardness, strength, or other desired property. Therefore, laboratory tests, whose results may be numerically expressed, have been devised to furnish us with information as to the likely behavior of the metal in service. Such tests, in general, consist in measuring comparatively definite physical quantities by simple experiments which may be rapidly carried out and whose results may be easily checked.

It is not yet easy to say which and how many of the various physical properties, which metals possess, are of direct importance in the construction of these automotive parts. The conditions under which a motor car must operate are unusual. Long, hard, uphill or sandy pulls, shocks from rought and choppy roads, brakes suddenly applied, continued high speed, all these subject the mechanism to stresses and strains, and combinations of destructive forces, the results of which are difficult if not impossible to calculate. It is not a question of resistance to simple static stresses, but of the ability of the parts to withstand dynamic forces or the work done by these forces. The phenomena embraced in the terms fatigue, vibration and shock become important.

Dynamic tests, designed to isolate and measure the physical properties which determine the behavior of steel under these conditions, have been suggested. However, the great complexity of the various facts which determine the results of such tests and the little understood influences of slight changes in test conditions have limited their use, with but few exceptions, to qualitative rather than quantitative results.

Of the many properties easily measured, the automotive manufacturer depends chiefly upon those obtained by the following tests:

First, the tensile test.

Second, the Brinell and scleroscope hardness tests.

Third, an impact test (in this country generally the Izod).

Fourth, thermal and metallographic investigation.

These tests, while not conclusive, nevertheless, when properly interpreted and supplemented by close observation of actual service, sufficiently define our steels for commercial purposes. Therefore, we will confine our discussion to the characteristics of these steels as disclosed by the above simple tests.

Chief reliance is placed in the tensile test. It will be readily admitted that the use of some sort of a dynamic test, which would more closely approximate the conditions of automotive service, would be more justified. Nevertheless, the permanence of the tension test and the general acceptance of its data by both steel producers and steel consumers, lead us to anticipate that its results, when supplemented with other information, will within limits tell us much of the probable dynamic character of the steel.

Briefly, the tension test is this: A bar of steel, of known dimensions, is subjected to a tensile load. This load is increased gradually, until rupture of the steel occurs. The maximum force so withstood by the bar is recorded as the ultimate tensile strength. The smallest load necessary to produce permanent set in the bar is designated as the elastic limit. Both of these are calculated on the basis of one square inch section. The percentage of increase in length and the change in cross section, due to the flow of the metal at the point of fracture, are also measured and calculated. The former of these is called the percentage of elongation and the latter, the percentage reduction in area.

Obviously, such a test does not duplicate the conditions to which the steel is subjected in actual motoring service. Its real value lies in our ability to correlate the data so furnished with the results of our other tests and the results of actual engineering experience. Tensile strength, elastic limit, reduction in area and elongation, these simple properties, when taken individually, convey little: but collectively, and with proper emphasis on their relation to each other, they form a sound basis for estimation of quality.

Motor car parts are with few exceptions of great enough size and mass to withstand many times the static load which they are called upon to bear. As a matter of actual practice, it is the ability to take punishment, such as shock, vibration, impact and the wear and tear of the roads, that we require of our materials; and it is the ability of a unit mass of steel to withstand work done upon it that we try to determine.

Remembering, then, that the physical properties, made evident by the tensile test, are properties of a test bar and are only indirectly properties of the steel tested, let us examine the results of this test in terms of the work actually done and the metal actually affected.

During the breaking of the bar, we are doing work; that is, we have measured variable force starting at the elastic limit, gradually increasing up to the ultimate strength and then decreasing to the breaking load, which moves in all a distance equal to the total elongation of the bar. Since both the force applied and the distance through which it moves are known, the work done is easily calculated.

Generated on 2024-09-08 15:49 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

The actual amount of the material in the bar, the usefulness of which is practically destroyed by this work, is more difficult to determine. Our reduction in area, however, gives us an indication of this quantity. When we examine the test bar after the test, it will be found that the metal directly back of the fracture is still able to withstand a slight amount of work; still farther back, more work; and so on until metal but slightly affected is reached. The reduction of area describes and is a rough measure of the degree of this condition. It is of more importance qualitatively than quantitatively.

Consider for a moment the following illustrations. Fig. 1 represents a fractured tensile bar of a material of low reduction in area, as characterized in certain bronzes. Fig. 2, a similar bar of material such as an alloy steel, showing high reduction in area. Let us, for the sake of argument, assume that the mean breaking strength and percentage of elongation were in each case identical. Thus, with no further evidence to go by, it would be assumed that the materials were equally strong and tough and equally suitable for our motor car part.

It will be observed, however, that there is a marked difference in the appearance of the two test pieces. The steel bar shows a marked necking down at the point of fracture, due to the local flow of metal between the lines "A"—"B" while the bronze bar has stretched almost uniformly throughout its entire length. Hence, although the same amount of work was performed in rupturing both test pieces, it can be readily seen that the mass of metal affected in the bronze was considerably greater than that in the steel. Consequently, the resistance of a unit mass of the material of bar No. 2 was greater and the reduction in area is a measure of this fact. The higher the reduction in area, other conditions being equal, the greater the ability of a unit mass of the steel to withstand work done upon it.

The tensile test may therefore be considered as a dynamic test where work is done at a slow rate. Its results, as a measure of work done and metal affected, while not numerically exact, are at least proportional to them. This relationship might, roughtly, be expressed as follows: Quality of metal as evidenced by the tensile test is equal to

$$\frac{\text{Work Done}}{\text{Metal Affected}}$$

which is proportional to

$$\frac{\text{Mean Breaking Strength} \times \text{Elongation}}{\text{K—Reduction in Area}}$$

where "K" is a constant, the value of which varies with the type of fracture, and the mean breaking strength is the average force applied to the bar after the elastic limit has been passed.

It is common practice, as a check, to supplement the tensile test with an impact test in which a notched test bar is broken at a rapid rate by a falling hammer. The Izod test, in this country, enjoys the most widespread use. The work done is recorded directly in foot pounds and the mass of metal so affected, due to the mechanical effect of the notch, is in each piece fairly constant.

Our hardness test, as determined by the Brinell and sceleroscope, is used as a check on our heat treatment processes and as an index to machineability and resistance to wear. The results are purely empirical and of value only when coupled with the observations of experience.

Difficulties will immediately arise if we endeavor to apply too literally the results of any of these tests to conditions greatly different from our test conditions. Other considerations based upon the metallographical makeup of the steel, may greatly change these results under the conditions of actual service. Steels, as a class, are composed of a mixture of crystalline and amorphous materials. The relative sizes, proportions, distribution and qualities of these constituents, play an all important part in the behavior of the steel, under various applications of forces. Metallographical and chemical investigation are doing much to determine this relationship between microstructure and physical

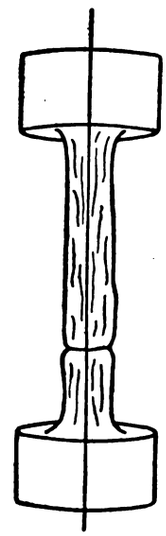


Fig. 1.

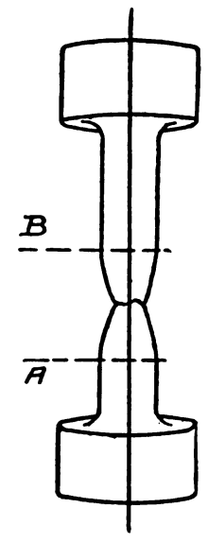


Fig. 2.

properties. However, in uniform materials, uniformly heat treated, these conditions are fairly constant, and except in special cases to determine soundness, metallographical investigation is largely confined to pure research.

Effects of Heat Treatment.

Steels for the parts now under discussion are invariably used in the heat treated state. The behavior of the steel under thermal treatment also bears a relation to its dynamic characteristics.

When a piece of steel is heated beyond its critical point, it undergoes a chemical and physical transformation. If thereafter it be slowly cooled, this transformation reverses itself and the material returns to its normal state. However, when the steel is quenched, the physical and chemical changes which took place during the heating have now no opportunity to reverse and the material, when cool, is consequently in a state of unstable equilibrium. This degree of instability is measured by the temperature to which we can subsequently reheat or "draw" the steel after quenching and still maintain our requisite strength. In other words, the higher the drawing temperature that the steel can withstand, the greater is its molecular stability and the greater is its resistance to any subsequent molecular change, whether the latter be produced mechanically or otherwise.

Other factors being equal, the steel with the highest drawing temperature will be the most satisfactory

Generated on 2024-09-08 15:49 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

for those automotive parts that require resistance to "fatigue."

But here again caution must be exercised lest our conclusions carry us beyond a logical point, because the metallographical size, nature and distribution of the constituents of the steel are also factors to be reckoned with.

We have indicated in the preceding paragraphs that the merit of a steel for motor car use was closely related to the results of the tension test; and that this relationship might be expressed by the proportion:

$$\frac{\text{Mean Breaking Strength x Elongation}}{\text{K—Reduction in Area}}$$

It is perfectly obvious that such a simple proportion as the above can in no way be an exact statement of the really complex relation which exists between the phenomena occurring in the tensile test and the exceedingly complex combinations of properties required for our various parts. Nevertheless, since this test so greatly influences the automotive manufacturer, in his choice of steels, we are justified in considering what further information it can supply us with.

The physical properties of our steels are direct functions of the drawing temperature. Thus the elastic limit, elongation and reduction in area may all be varied over wide limits by heat treatment.

It therefore follows that our merit number, as previously computed, will also change in value according to changes in the drawing temperature and will in a given steel reach a maximum at some definite temperature.

For example, a hardened but not drawn bar of high carbon steel may show an elastic limit of say 175,000 pounds per square inch. Nevertheless, it can be readily seen by breaking the bar with a hand hammer that this strength of little use for the parts under discussion. Due to the slight elongation and reduction in area possessed by the bar, these factors in our equation will be small and our merit number will be very low, in spite of the relatively high elastic limit. If we now reheat or draw the bar, we find that although of less strength as measured by elastic limit, it will easily withstand our efforts with the hand hammer. A further increase in temperature still further increases the amount of energy which must be expended before breakage occurs, until a maximum point is reached where the decrease in tensile strength and elastic limit is not compensated for by the corresponding increase in elongation and reduction in area. Further elevation of the drawing temperature beyond this point results in a decrease in merit until the critical point is reached, with its accompanying fundamental changes in qualities. This drawing temperature at which maximum merit occurs is different in different types of steel and is fairly independent of the carbon content. This consideration is important in comparing the suitability of the various steels for different uses and in defining our practice in allotting a particular analysis of any given type of steel to a particular part.

Thus we find that the steels in which this temperature of maximum merit is naturally low are used exclusively in the condition resulting from low drawing temperatures. This is the case with silico-nickel steels which are widely used for hard light armor plate.

Our most widely used spring steel is of an analysis which develops the necessary spring requirements of strngth, etc., at a drawing temperature but 60 deg. removed from the temperature of maximum merit for that steel.

It is common practice in the manufacture of large carbon steel forgings to meet the elastic limit requirements in so far as possible by carbon additions and thus maintain a high drawing temperature. Since there is, then, a definite drawing temperature, at which the dynamic properties required in automotive steels are developed to their maximum, for each particular steel analysis, there is, consequently, a corresponding definite elastic limit at which the particular steel may best be used.

Most of our major automotive parts require, owing to the limitations imposed by design, minimum strengths of a relatively high order. Also the successful operation of these parts, under the difficult service conditions, pre-supposes the development of the merit index to a high degree.

Alloy Steels Necessary for Certain Parts.

Carbon steels may develop under suitable heat treatment elastic limits which are sufficient for most of these parts, but their use is promptly excluded where the requirements exceed 80,000 pounds per square inch, and even for requirements under this figure the merit index is of a lower order than is desired.

Accordingly, our automotive alloy steels have been developed, which not only will show higher elastic limits than those obtained in carbon steels, but also for any given elastic limit, demanded by design, will exhibit resistance to fatigue, vibration, shock and wear, far greater than that of any carbon steel.

This development has been coincident with and in a large measure responsible for the development of the automotive industry.

The commercial factors, as defined by the adaptability of these materials to the various mill processes of manufacture and the subsequent operations of fabrication such as machineability and general adaptability to shop conditions, have in a like manner been improved until it may now be fairly said that through the use of alloy steels, the automotive manufacturer can build a better product at a cheaper price.

BLAST FURNACE HEARTH GAS ANALYSES

In the analytical work on blast furnace hearth gases, being performed by the United States Bureau of Mines, the composition of the gases in the tuyere plane has been determined at two furnaces in the Pittsburgh district. One, a furnace making ferro-manganese, showed conditions practically identical with Southern practice on basic or pig iron. The other, making basic iron, showed penetration of oxygen to a further distance than obtained in the Southern furnaces. Arrangements have been made with a blast furnace operation at Youngstown, Ohio, to obtain samples at other planes up the bosh. It is hoped that this work may bring forth some valuable information.

HEAT TREATMENT OF NON-FERROUS ALLOYS

At the Pittsburgh, Pa., experiment station of the Bureau of Mines heat-treatment experiments, including quenching and annealing, have been conducted on a number of cast non-ferrous alloys.

Generated on 2024-09-08 15:46 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

Use of Liquid Fuel in Metallurgical Furnaces*

Success in Using This Type of Fuel Depends on Furnace Design, Proper Methods for Its Distribution to the Furnace, and on Burners Which Will Atomize the Fuel So Thermal Value Is Utilized.

By R. C. HELM†

WITH the variations in economic conditions which have existed in different localities in the past few years, as regards the status of coal converted into condenser gas for use in metallurgical furnaces, an added impetus has been given to the study of the proper application of various types of liquid fuels where such fuels were available at prices which would permit of their economic use. Tar and fuel oil are the most common of the liquid fuels which are economically available for use in metallurgical furnaces and this paper has, therefore, been confined to their use only.

The use of oil as a fuel in furnaces for metallurgical purposes dates back a good many years, and the demand for it is constantly increasing. Originally, the oil was used in its crude form without the removal of any of the more volatile hydrocarbons. Naturally, the low flash point of such oils made them unsafe to handle. Moreover, the development of wider uses for these lighter oils demanded their extraction from the crude. The removal of these lighter hydrocarbons raised the flash point of the residue considerably, giving a resultant product which could be used with more safety. A large proportion of the oil now used as fuel is obtained as a residue in this manner, although some residues are so viscous and of such poor quality as to make them unsuitable for economic use. Other types of fuel oil developed from more complete refining operations are also adaptable for fuel purposes in metallurgical furnaces.

The calorific value of the fuel oils in common use varies from about 141,800 to 152,400 Btu. per gallon with corresponding density as measured by the Beaume hydrometer of 30 deg. to 12 deg. at a temperature of 60 deg. F. As oil is purchased by the gallon, the heavier but more viscous fuel oils, therefore, have the higher thermal values. The thermal value of the oil, however, does not necessarily indicate its adaptability for furnace use, as other features such as the content of impurities and size of furnace installation must be taken into consideration in deciding whether the heavy and more viscous oils should be used in preference to the lighter and more fluid oils.

Specifications under which fuel oils are purchased, usually require that the fuel oil shall not contain over one per cent of water and foreign matter, which are likely to interfere with the use of the oil due to clogging of burners and interference with the operation of valves. It is commonly agreed that the flash point should not be less than 150 deg F. (closed cup) as a matter of safety, although oils with a lower flash point are being used. Specifications for viscosity will vary dependent on the arrangement of the system used for conveying the oil from storage to the burner. The sulphur content of fuel oil, which may run as high as 4.0 per cent in some oils, is of great importance when used in connection with very high temperatures, such as are obtained in open-hearth practice, where the products of combustion come into direct contact with the charge during the melting down period. Under these circumstances, the percentages of sulphur may have to be limited in specification to 0.75 per cent or less depending on the open-hearth practice used. However, in certain localities, the less cost of high sulphur fuel oils as compared with low sulphur fuel oils has led to the development of an open-hearth practice whereby limited percentages of high sulphur oils can be used without detrimental effect to the finished product. With such a practice, specifications may be more liberal with respect to limiting the percentage of sulphur allowed in the fuel oil.

The introduction of the by-product coke plant increased the available amount of coal tar to such an extent as to result in making coal tar available as a liquid fuel for use in metallurgical furnaces. In addition to tar, the by-product coke plant also furnished a supply of gas for the same purpose. The usual proximity of the by-product coke oven plant to the open-hearth plant supplies a very good opportunity of utilizing both coke oven gas and tar as open-hearth fuel to the economic benefit of both plants.

As the production of tar goes hand in hand with the production of gas, the natural development of the use of both these fuels has resulted in the practice of using them in combination as fuel for the open-hearth furnace. The use of coal tar only has also been advantageously developed. As tar can be burned more advantageously where high temperatures are required, its use in steel plants has been chiefly confined to open-hearth practice.

Tar has a thermal capacity of about 155,000 to 162,000 Btu. per gallon. Coke oven gas as used is debenzolated and has a thermal capacity averaging 540 Btu. per cubic foot.

Many types of furnaces for metallurgical use have been equipped for use of liquid fuels. As far as the supply of air for combustion with liquid fuel is concerned, these types may be classified into three groups: (1) non-preheating furnaces in which the air is admitted to the combustion chamber at atmospheric temperatures; (2) regenerative furnaces operating on the

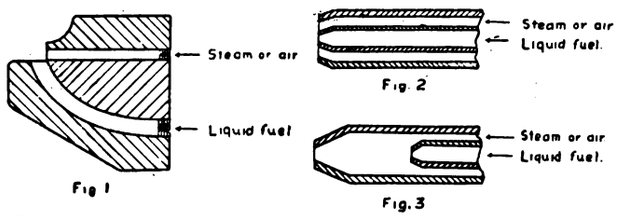
*Paper read before the American Iron and Steel Institute, at New York, October 27, 1922.

†Director, Physical Laboratory of the American Steel and Wire Company, Worcester, Mass.

Generated on 2024-09-08 15:46 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

reversing principle in which the air is preheated in a checker chamber before entering the combustion chamber, the checker chamber deriving its heat from the waste gases; and (3) recuperative furnaces in which the air for combustion is preheated by passing through a set of flues which alternate with flues through which the hot waste gases flow in a counter direction or at right angles to the direction of flow of the air.

While the use of liquid fuel has been adopted as a matter of expediency in some cases, the range of application includes open hearth; crucible, soaking pits; billet heating, forge, annealing, hardening and tempering furnaces; and a variety of furnaces for special heat treating operations. The use is also extended to a variety of furnaces used in the non-ferrous metal industry. The scope of this paper has been restricted



Figs. 1 to 3—Showing the principle used in some types of liquid fuel burners.

to cover chiefly the use of liquid fuels to open-hearth furnaces and in furnaces particularly adapted to use in the wire drawing industry.

The use of coal tar and the heavier oils of 12 deg. to 20 deg. Be. requires careful heating of the oil in supply tanks so that they can be sufficiently reduced in viscosity to enable them to be pumped to the burner at the furnace. As heating vaporizes any light oils present, tanks should be vented at the top to permit of their removal from the system. The lighter oils having a density of 20 deg. to 30 deg. Be. are sufficiently fluid so that they may be pumped to the burner with

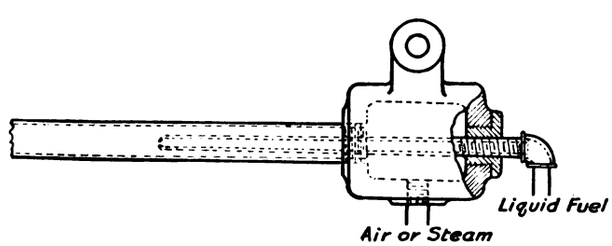


Fig. 4—Liquid fuel burner for open-hearth furnace.

little heating except in particularly cold weather. Heating of tar and heavy fuel oil is also essential in order to obtain proper atomizing of the oil at the furnace. Failure to provide sufficient heat to heavy fuel oil or tar cannot help but result in unsatisfactory results from the furnace in which it is used due to the failure of the burner to perform its proper function.

After bringing the liquid fuel to the furnace under suitable temperature for atomizing, the success of using it depends on burner design, furnace construction, and the proper application of the burner to the furnace, so that the thermal value of the liquid fuel may be utilized at the proper time with the highest efficiency to produce the results required. For obtaining the highest thermal efficiency, it is necessary that burners be designed so that they will break up or atomize the liquid fuel into very minute parts in order that the greatest amount of surface may be offered to the air required for combustion.

In order to accomplish this purpose, many kinds of burners have been designed for private use or patented and placed on the market for general furnace use. These types of burners are intended to accomplish atomization by, (1) mechanically breaking up the liquid fuel into minute particles: (2) by breaking up the liquid fuel with an air or steam spray; and (3) by vaporizing. Attempts made to apply the last mentioned process to fuel oil by superheating to a temperature sufficient for vaporizing have not as yet been demonstrated as practicable due to the deposition of solid coke in the vaporizing chambers with consequent clogging of the system. Mechanical atomization, while practiced to a very large extent with steam boilers, has unfortunately not been developed for general application to metallurgical furnaces. Burners which find extensive use in metallurgical furnaces, however, are those types which accomplish atomization by spraying either with steam or compressed air under variable pressures dependent on furnace requirements.

There is quite a large field for using different principles in varying the design of burners which depend on steam or compressed air for atomizing the liquid fuel.

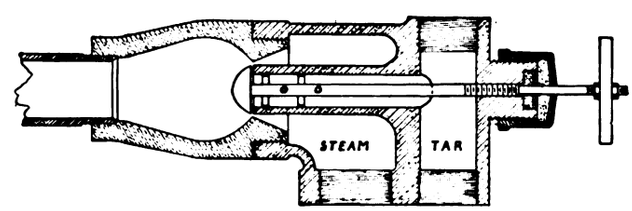


Fig. 5—Krause burner for liquid fuel.

A few of the principles which have been used in burner design will be described and illustrated so that a general idea may be obtained of the possibilities for variation. Atomizing burners are generally classified in two groups, one of which accomplishes atomization outside the burner, the other inside the burner. Fig. 1 illustrates a very simple arrangement whereby the steam or air jet passes directly over the oil jet, creating a suction effect which assists in the efficiency of atomizing outside the burner. Fig 2 illustrates another principle in common use where the oil is supplied through a central pipe to the tip of the burner. The steam supply running also to the tip of the burner surrounds the oil supply line. Atomizing is, therefore, accomplished externally in the furnace. Fig. 3 shows a burner with a chamber beyond the end of the fuel nozzle and provides for atomizing before the fuel enters the furnace. This type of burner may be altered so that the air and oil chamber has a Venturi shape and is known as the injection type. This principle is used with the idea of obtaining velocity in assisting to atomize the liquid fuel. Either steam or air may be used for atomizing with any of these general types of burners. The shape of the nozzle may be round or flattened in almost any type of burner to meet the requriements of furnaces for special purposes.

The pressure of air or steam required for atomizing with any burner is dependent on the furnace design and the character of the liquid fuel. Air pressure for the lighter oils may be as low as a few ounces per square inch where small furnaces are used. With the heavier liquid fuels, where steam is commonly used, the pres-

Generated on 2024-09-08 15:50 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

sure on the line may run as high as 140 pounds per square inch.

Use of Liquid Fuels in Open-Hearth Furnaces.

The price of fuel oils in localities where large tonnages of open-hearth steels are produced is usually so high as to prohibit its use in competition with producer gas. The supply of by-product coke oven coal tar, however, ranging in quantity with different kinds of coal from approximately five to 13 gallons per ton of coal used, is available in sufficient quantities and at prices which make its use economically attractive, as far as

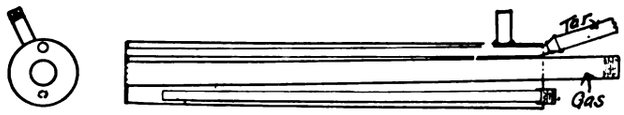


Fig. 6—Combination water-cooled tar and coke oven gas burner.

the supply lasts, for use either alone or in combination with coke oven gas in open-hearth furnaces. Where the open-hearth practice has been developed for the use of tar alone or in combination with coke oven gas with consequent closing down of the gas producers, fuel oil may be substituted for tar to permit continuous furnace operations if the regular supply of coal tar is interrupted for short periods of time. As the equipment necessary for using tar is similar to that used for oil, such a change may be quickly accomplished. It is a good plan, however, when making such a change to clean out the system with steam under high pressure in order to free the pipes of any carbonaceous deposits which may have collected in them.

Installations of special equipment for handling liquid fuels are required, the cost of such equipment, however, being comparatively moderate. Storage tanks of variable capacity will be required to meet the demands of the individual plant. The use of large storage tanks at by-product coke oven plants, however, makes it unnecessary to provide large tank installations at the open-hearth plant. Where fuel oil is depended upon alone, possible delays in transportation due to distance from supply stations may necessitate very large storage tanks for even moderate sized open-hearth installations. All storage tanks for tar and the heavier fuel oils must be equipped with internal steam coils in order to supply sufficient heat to decrease its viscosity to such an extent that it may be readily pumped through the furnace supply pipes and be better atomized at the burner. The installation of a regulator in the steam line is of considerable benefit in maintaining proper temperature. The temperature of the tar in the tank found most desirable in practice varies from 125 deg. to 150 deg. F. The temperature used for pumping and free circulation of heavy fuel oils is usually around 10 deg. F. Higher temperatures tend toward the deposition of hydrocarbon which may cause clogging of the burner. Lower temperatures cause poor atomization and, therefore, dripping at the burner with consequent loss of thermal value.

When unloading from tank cars, strainers for removing solid mechanical impurities are placed in the pipe line to the tanks if unloading is accomplished by gravity or in the suction line of pumps when it is necessary to use the latter means of unloading. Such straining is usually through baskets of 3/16-in. mesh screens, set in suitable castings in the pipe line.

The liquid fuel is pumped from the supply tanks through pipes to the various furnaces. Pumps installed for this purpose are of both the duplex and triplex type, governed to maintain a steady pressure on the line. Where trouble is experienced with pulsations, relief is sometimes found by applying compressed air directly to the tank. All pumping equipment should be in duplicate in order to prevent serious delays in furnace operation during periods when it is necessary to make repairs to the pumps. When steam is depended upon for pumping, an auxiliary electrically driven pump will provide additional flexibility in case of breakdown or vice versa.

In order to convey tar and the more viscous fuel oils to the furnaces, pipe lines are arranged so that, after the various furnaces have been supplied, the line is returned to the pump. It is necessary in some cases to pump as much as 50 per cent more fuel than is actually consumed by the furnaces. Both the supply and return lines should be run parallel with a steam line and the three enclosed with a heavy asbestos covering to prevent cooling of the fuel during circulation. The size of lines for the fuel should usually not be less than three inches in diameter as smaller lines cause too much restriction to oil flow. Since storage tanks are generally isolated from the open-hearth building, it may be necessary to reheat the fuel as soon as it enters the building. A steam jacketed heater is satisfactory for this purpose. Reheating of the liquid fuel with a similar steam heater may also be necessary at the furnace, before the fuel enters the burner.

A practice whereby a limited amount of cheaper high sulphur fuel oil may be used in connection with the more costly low sulphur oil without detriment to the quality of the finished product has been in use for

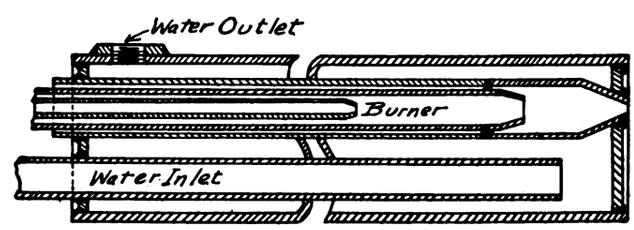


Fig. 7—Water-jacketed liquid fuel burner.

a number of years at an open-hearth plant in the east where the cost of fuel oil justifies its entire use in preference to producer gas. The high sulphur oil obtainable has a density averaging about 15 deg. Be. and is handled through a circulating oil system as described above. This oil is circulated at about 150 deg. to 160 deg. F. The low sulphur oil, averaging 25 deg. Be. and being considerably less viscous, is supplied to the furnaces through one pipe line which is dead ended after supplying the last furnace in the system. The temperature of the lighter oil at the pumping station varies from about 90 deg. to 100 deg. F. The furnaces are operating entirely with a cold pig iron and scrap practice. During melting down of the charge, low sulphur oil is used entirely. After the slag completely covers the charge, high sulphur oil is used for the completion of the heat. The furnace supply lines for both the high and low sulphur oils are brought together just before reaching the three-way reversing valve. Valves for shutting off either the high or low sulphur oils, as the practice demands, are conveniently arranged in the separate oil lines just before the two supply lines are joined.

Generated on 2024-09-08 15:49 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

As tar is more difficult to atomize than even the heavier fuel oils, the type of burner used is worthy of considerable attention. The most common type of burner used for atomizing tar is illustrated in Fig. 4, where the tar is introduced through a central nozzle with the steam chamber entirely surrounding it. With burners of this type, various alterations of design have been tried with the idea of increasing the efficiency of atomization by inserting a valve spindle through the tar supply pipe, and attaching a ball or cone to the spindle at the fuel orifice. The ball or cone diverts the tar directly into the path of the steam giving better

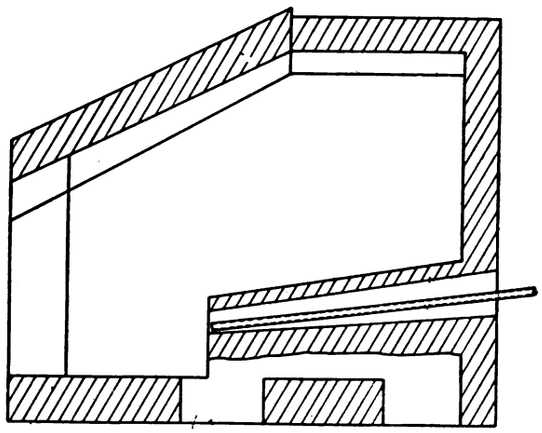


Fig. 8—Oil burner in brick tunnel through end of open-hearth furnace.

opportunity for atomization. Another modification of this burner may be obtained by plugging the end of the nozzle and drilling holes at various points throughout its circumference through which the liquid fuel is forced into the path of the steam.

Fig. 5 illustrates a burner, designed and patented by Mr. Krause of the South Chicago plant of the Illinois Steel Company, intended primarily for increasing the efficiency of atomization when burning tar. Its construction lends itself readily, however, to the application of atomizing fuel oils with great efficiency. It is quite simple in design but very effective in atomizing tar. The tar supply passes through the central part of the valve to the button at the end of the valve stem where it is sprayed in fan shape into the path of the steam. Small projections from the valve stem to the wall of the valve prevent vibrations. The steam chamber is conicled in the direction of the tar outlet so that maximum velocity is obtained at the area of contact between the tar and oil. The atomization of the tar accomplished in this burner proves very effectual as judged by combustion conditions within the furnace. The burner also has the advantage of being quickly cleaned by screwing the valve stem in or our if clogging occurs at the tar orifice.

The steam pressure on the line supplying steam for atomization varies from 50 to 125 pounds per square inch, dependent on furnaces and burner construction. Likewise, the amount of steam per gallon of oil atomized varies from about three to six pounds. Dry steam is essential for good atomization, steam separators being used where necessary at advantageous positions on the line to obtain this condition. While the amount of steam seems relatively small, it is an item which should not be neglected in determining the type of burner to be used. Compressed air has not proven satisfactory for the atomization of tar. As fuel oils can be atomized with compressed air, however, tests have been conducted at an open-hearth plant using fuel oil only to determine whether steam or compressed air was cheaper. Such tests showed a net saving of seven per cent in the amount of fuel oil consumed in favor of compressed air, using a type of burner found to give consistently good results in furnace operation.

With the temperature conditions existing on the ends of an open-hearth furnace, it is necessary to provide some means of preventing the burner from being destroyed. This may be accomplished by providing mechanical means of swinging the burner out of the furnace when not in use; by placing the burner within a water jacket; or by building a tunnel, which may or may not be water jacketed, into the end of the furnace. As the majority of open-hearth furnaces on which liquid fuels are now used were designed primarily for the use of producer gas, there is commonly not sufficient space between furnaces to permit of the use of swinging burners.

In cases where tar is to be used in combination with coke oven gas and the introduction of both fuels has been found to give the best results when admitted into the end of the furnace, the gas burner and tar burner are combined in the same water jacket as illustrated in Fig. 6. Coke oven gas, due to being very light, is always introduced under the tar or oil, the heavier liquid fuel acting as a blanket to keep the lighter gas from rising and burning at the roof of the furnace with consequent short life of the furnace roof. The objection to using a burner of this type is that the tar and steam both must pass through a long atomizing chamber surrounded with water. The cooling effect of the water tends towards both condensation of the steam and liquefaction of the tar. The shape of the gas tip used with the combination coke oven gas and tar burners is either round or flattened. As the details of furnace construction vary, it will be necessary to de-

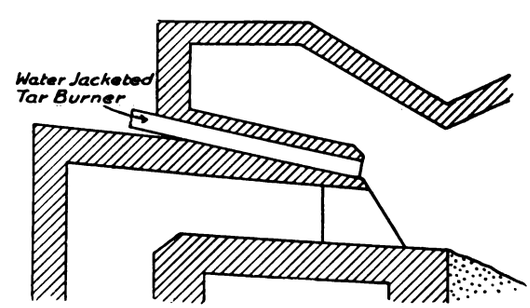


Fig. 9—Tar burner in producer gas furnace.

termine by experiment whether the coke oven gas will give better results with either the round or flattened nozzle.

With furnaces designed for introducing tar alone at the ends of the furnace, a water jacketed burner similar to that illustrated in Fig. 7 may be used. This type of burner does not possess the objectionable feature of bringing the burner chamber in direct contact with the cooling water. A similarly designed water jacket may also be used in connection with the combination tar and coke oven gas burner.

A brick tunnel may be built into the furnace from the end wall as shown in Fig. 8. The high temperatures

Generated on 2024-09-08 15:46 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

existing in the furnace may necessitate water-cooling in order to insure necessary life of the tunnel. In some furnaces, however, using fuel oil and having a tunnel similar to that shown in Fig. 8, a small amount of steam, insufficient to interfere with furnace operation, is kept passing through the unused burner, neither burner or tunnel being water-cooled.

The extent to which changes in design of furnace ends is justifiable is in a measure determined by the quantity and type of liquid fuel available. Fig. 9 illustrates a method used for introducing a tar or oil burner into the end of a furnace designed for use with producer gas. Other features of furnace design may require the burner to be introduced so that its tip partly extends into the gas port, instead of taking the position shown in Fig. 9. In very large furnaces, better fuel distribution may at times be had by using two burners on each end of the furnace, each burner being located toward the side wall of the furnace.

Where a steady supply of liquid fuel is available, the construction of the furnace ends may be considerably simplified as illustrated in Fig. 10. With this design, the air for combustion is admitted through two uptakes at the corners of the furnace and the cinder pockets are combined into one chamber. Both checker chambers at each end of the furnace are utilized for heating the air. Fig. 8 shows the modification of port construction applied to a 50-ton oil burning tilting furnace.

The location of the burner in the furnace for either tar or fuel oil is of great importance, and in practice differs as to the height above and angle which it makes with the bath line and the length introduced into the

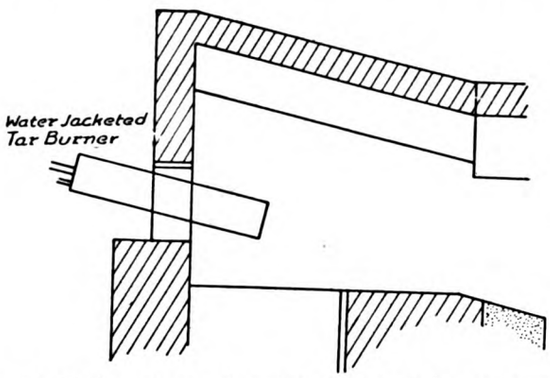


Fig. 10—Design of open-hearth furnace end for tar burning.

furnace. It should be placed so that luminosity is obtained as soon as the fuel reaches the furnace hearth. In connection with this, it is important that the burner be so placed and the port ends so constructed that proper direction of atomized fuel and air for combustion will give the most efficient melting down and prevent melting of the roof. As different types of burners vary in the thoroughness of atomization, the type of burner used will have some bearing on its location.

The use of a satisfactory quality of liquid fuel alone requires little or no changes in open-hearth practice. It has been used with furnaces up to 200 tons capacity. The quantity of fuel consumed per ton of ingots produced will, however, vary according to the open-hearth practice used at different localities. Furnaces operating with a combination coal tar and coke oven gas practice use variable percentages of each, depending on local conditions. Commonly, however, about 50 per cent of the heat required is derived from each source. Some plants have experienced a reduction of 10 to 15 per cent in the time of heats under similar conditions and a reduction in furnace repairs, as compared with furnaces operating with producer gas. Where waste

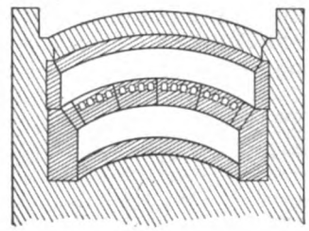


Fig. 11—Cross section of earlier type of coal fired, old process patenting furnace.

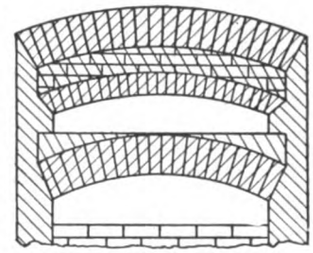


Fig. 12 — Later design of coal fired, old process patenting furnace.

heat boilers are installed, the less volume of gases from liquid fuel burning, as compared with furnaces operating with producer gas, results in a less amount of heat available for use in the boilers.

Application of Liquid Fuel to Heat Treatment of Wire Products

Fuel oil has proven of considerable value in its application to furnaces used in the continuous heat treatments of both high and low carbon steel rods or wire. The heat treatments in common use in the production of steel wires are patenting, hardening and tempering, and annealing. The two latter treatments mentioned are quite familiar. The patenting process, however, finds its chief commercial application throughout the wire producing industry. A brief discussion of the patenting process will serve to indicate the adaptability of fuel oil to the furnaces required to carry on this heat treatment. The patenting process is intended to impart to the wire a uniform degree of toughness and temper which will permit of drawing the wire through dies to obtain the proper size and quality demanded for various commercial purposes. The patenting process of wire is accomplished by two general methods. One of these types is known as old process patenting, in which the wire or rod is continuously passed through a furnace, where it is required to reach a temperature of approximately 1,700 deg. F., after which it passes out of the furnace, through unrestricted air space, to be again wound on reels to facilitate handling. The second type of patenting is known as double lead patenting, in which the wire or rod is passed continuously through a hot metal bath, usually lead, where it is heated above its critical temperature and passes immediately into another lead bath having a temperature below the critical temperature of the steel. Each of these processes has its particular use in the production of various grades of wire for definite commercial uses. The double lead process, however, on account of obtaining better temperature control surpasses in permitting the production of high carbon wires of great strength and toughness.

With the introduction of old process patenting to the wire industry, furnaces were generally designed for the use of coal, except where natural gas was available, and coal fired furnaces for this purpose are still used where economic conditions are favorable. The process requires that a large tonnage of cold rods or wire pass through the furnace and exit at comparative-

Generated on 2024-09-08 15:47 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

ly uniform temperatures. Early furnace designs, such as illustrated in the furnace cross section of Fig. 11 provided for a large amount of brick work which acted as a reservoir for radiating heat to the rods or wire as they passed through the tubes. Heat was supplied from a coal fire at the end of the furnace, the gases supplied from a coal fire at the end of the furnace, the gases passing under the tube brick arch to the opposite end of the furnace, returning the full length of the

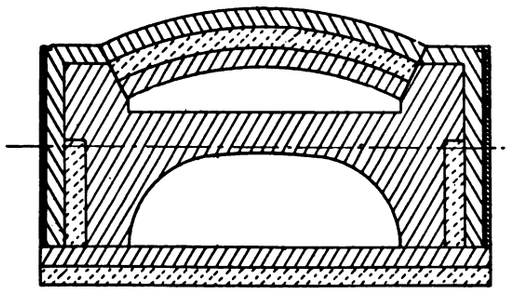


Fig. 13A—Cross section of old process patenting furnace.

furnace over the top of the tubes and then passing to the flues. A later development of the furnace is shown in Fig. 12 and eliminates the tube brick arch, providing, therefore, for the passage of the wire directly through the furnace gases. While the latter design reduced the cost of coal per ton of product, furnace temperature control was no better than with the original type of furnace and the possibility for fluctuations of temperature during cleaning of fires still existed. By using fuel oil, furnace designs for old process patenting could be readily varied in order to utilize the full effects of the heat of combustion at a position in the furnace which would most favor thorough heating of the wire or rods to the desired temperature. The design of a patenting furnace in which very efficient heat treatment is performed is illustrated in Fig. 13. The arch in the furnace is somewhat similar to that of a longitudinally bisected frustum of a cone, using the bisected plane as a base. The burner is introduced in the end of the furnace at the narrow end of the cone and is of the type illustrated in Fig. 2 with a nozzle of sufficient length to extend within the furnace wall. Air for combustion is admitted around the burner. Dry steam under 125 pounds pressure is used for atomization. The maximum temperature generated within the furnace is obtained at the most desirable position in the furnaces or just before the wire passes out of the furnace into the air. The furnace gases pass over the top of the arch and exit into a flue on the same end of the furnace in which the burner is placed. As the wire travels in the opposite direction to the furnace gases, opportunity is presented for both gradual heating of the wire and utilization of heat in the waste gases.

The same type of furnace is utilized for heating the lead kettle when the double lead patenting process is used. A perforated brick arch is placed in the area marked "B-B" Fig. 13 B on which the lead kettle rests. The hot gases pass up through the interstices of the arch, entirely surrounding the bottom and sides of the kettle, after which they leave the furnace in the same manner as described above, supplying an opportunity to utilize the waste gases for reheating the wire before it enters the lead kettle. The colder lead bath used with this process obtains the greater proportion of its heat from the hot wire entering it although additional heat may be bypassed from the hot lead kettle furnace, if necessary, to the colder lead kettle.

If the cold lead pan is removed from the end of the furnace and replaced with a trough through which is circulated a supply of quenching oil, then we have an oil-fired continuous hardening equipment. For drawing the temper, a separate oil-fired lead kettle is arranged back of the quenching oil troughs. The same design with lead kettle in place may further be used for the continuous annealing of wire in lead.

Furnaces of this type consume much smaller quantities of fuel per hour as compared with open-hearth furnaces. Burners are, therefore, smaller in all details and the possibilities for clogging of burners due to mechanical impurities in the oils is much greater than experienced where consumptions are quite large as in open-hearth practice. Greater care must, therefore, be exercised in keeping a clean supply of oil flowing at all times.

With large tonnages of wire or rods to be handled, it is desirable to segregate similar heat treating equipment and use several separate oil supply systems rather than attempt too large an individual installation. The arrangements for supplying fuel oil to the various furnaces have been described with this idea in mind.

While fuel oils having a density averaging 15 deg. Be. require the use of an elaborate system for handling, their cheapness as compared with the lighter oils justifies the installation required for handling them for furnaces of the above type.

Fuel oil is brought to the storage tanks by tank cars where it is unloaded by pumps having strainers in the suction line. It is not customary to pump from storage tanks directly to the burners as intermittent unloading of oil is too likely to cause a general drop of temperature in the storage tank which would interfere with circulation and atomization. Transfer pumps are, therefore, used to pump the fuel oil from the storage tank into the tank in which it is to be used for furnace supply. Steel tanks used for mill supply are usually placed underground in concrete pits as this assists in keeping the oil at the desirable temperature for pumping. As it is necessary to have each tank vented, vents have been surrounded with small circular steam pipes

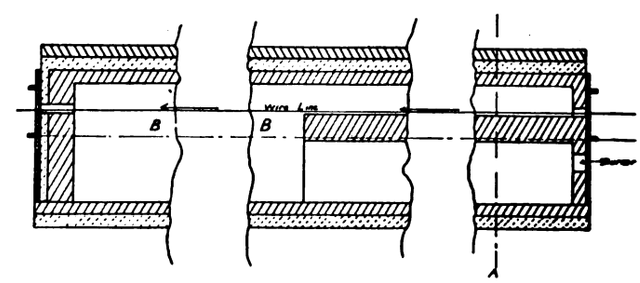


Fig. 13B—Longitudinal section through middle of old process patenting furnace.

having jet holes several inches apart pointing towards the center for the purpose of smothering the fire in case of ignition. Steam valves for controlling this feature have been placed conveniently at considerable distance from the tanks. Both sets of tanks are equipped with steam coils for heating the oil and all pumps are in duplicate to avoid delays in case of the necessity for repairs.

Generated on 2024-09-08 15:48 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

As straining is of great importance with small oil consumption per burner, strainers are inserted in the suction line of both the transfer and mill supply pumps, in order to afford all the opportunity possible to remove mechanical impurities. Strainers used for this purpose are illustrated in Fig. 14 in which a cylindrical basket made from wire gauze having 25 meshes per inch is used. Each pump has two strainers with suitable valve arrangements in the suction line so that the strainers may be cleaned without interruption to pumping. Both pumps and strainers when located in places subject to severely cold weather are steam jacketed.

The fuel oil is circulated as described for tar or heavy fuel oil at open-hearth plants with the same provision for combining the supply and return oil line together with a steam line. A stand-pipe of the same diameter as the supply line is, however, inserted in the return line of the system. The stand-pipe acts as a

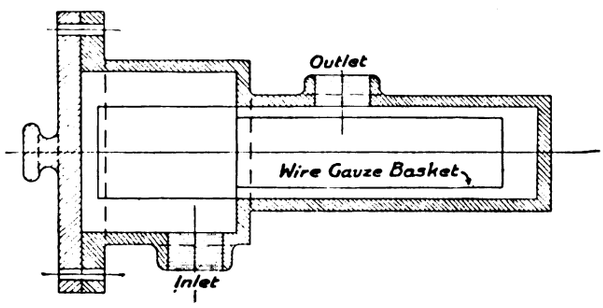


Fig. 14—Oil strainer.

reservoir and also serves to reduce the effects of pump pulsations which are particularly aggravating with small oil consumptions per burner. A valve is placed at the top of the stand-pipe to regulate the amount of oil returned. Oil supplied under a pressure of 35 to 40 pounds per square inch and steam under pressure of 125 pounds per square inch give the most satisfactory operating conditions. Dry steam is not only desirable but essential and steam separators are used in the line where necessary.

The above describes the system used for handling heavy fuel oil for several supply systems, accommodating a fairly large number of furnaces. The lighter fuel oils may be handled with less attention to their temperature. Where small heat treating furnaces are required for use in isolated places, the lighter grades of fuel oil requiring no elaborate methods for handling can be utilized quite favorably by the installation of a small pressure blower and fuel tank, the blower supplying both the air for atomization and pressure for forcing the fuel from the tank to the burner.

Conclusions.

Liquid fuels when available at satisfactory prices may be adapted to a large variety of furnaces used in conducting metallurgical operations. The relatively small initial expenditure required for its application and the ease of manipulation of furnace temperatures make the use of liquid fuels quite attractive. Success in using this type of fuel depends on furnace design, proper methods for its distribution to the furnace, and on burners which will thoroughly atomize the fuel. In the future development of the use of liquid fuel for metallurgical furnaces, there are at least two important principles to consider in an effort to obtain further economy. One of these is the adoption of the principle of mechanical injection now used quite extensively with boilers, and the other, the use of the recuperative principle wherever it can properly be applied in the construction of furnaces which now obtain their air for combustion at atmospheric temperatures.

USE OF OXYGEN IN METALLURGICAL OPERATIONS

Use of oxygen in connection with the enrichment of the blast in the blast furnace and in practically all phases of pyro-metallurgical work will furnish the key to success in the further development of such metallurgical operations, according to Dr. F. G. Cottrell, formerly director and now consulting metallurgist of the United States Bureau of Mines, who first directed the bureau's attention to this subject. Through this enrichment process, it is hoped to increase the efficiency of metallurgical operation with a resultant production of metals at lower cost and possibly the use of lower grade ores.

The Bureau of Mines now has outlined plans for two studies which will be carried on simultaneously. The first will cover the present-day processes for the production of oxygen, in order to determine the feasibility of attempting to produce oxygen, or oxygenated air, in such amounts and at such a cost as to permit of its use in metallurgical operations. The second study will be devoted to the feasibility of using oxygen, or oxygenated air, in metallurgical operations.

Because of his interest in this investigation, M. H. Roberts, vice-president of the Franklin Railway Supply Company, was asked to select an advisory committee to work with the Bureau of Mines and to act as chairman of this committee. The committee will consist of Dr. F. G. Cottrell, director of the Fixed Nitrogen Research Laboratory; Prof. W. L. DeBaufe, chairman of the mechanical engineering department of the University of Nebraska; Dr. D. A. Lyon, chief metallurgist of the Bureau of Mines; Dr. R. B. Moore, chief chemist of the Bureau of Mines; Dr. R. C. Tolman, professor of physical chemistry and mathematical physics, California Institute of Technology; J. W. Davis, mechanical engineer of the Bureau of Mines; F. W. Davis, metallurgist of the Bureau of Mines; Frank Hodson, president of the Electric Furnace Construction Company, and P. H. Royster, assistant metallurgist of the Bureau of Mines.

Previous to the war, some work was done in Belgium on the enrichment of the blast with oxygen in connection with the smelting of iron ores in the blast furnace. In the United States, the late J. E. Johnson, Jr., was interested in the possible use of oxygen in metallurgical operations and carried on some experimental work along these lines previous to his death

MEETING OF ELECTRIC STEEL FOUNDERS' RESEARCH GROUP

The chief executives and the operating officials of the companies comprising the Electric Steel Founders' Research Group recently held a three-day meeting at Wernersville, Pa., at which exhaustive progress reports were presented on researches being conducted by the organization into annealing, core practice, facing practice, furnace practice, and the elimination of slag from castings.

The group members report that the standardization of practices has recently been extended to cover methods of chemical analysis.

Generated on 2024-09-08 15:50 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

Heating Furnaces for Blooms, Slabs and Billets*

Selection of Fuels—Types of Furnaces—Efficiency Tests—Recommendations with Respect to Roof, Hearth, Skids, Burners, Regulators and Meters, Pusher, Roof Recuperator, Discharging and Charging Mechanism, Insulation, Water Cooled Devices, Etc.

By W. P. CHANDLER, JR.†

I HAVE been asked to prepare a paper on "Heating Furnaces for Blooms, Slabs and Billets," with special attention to fuel economy. If taken broadly, this subject would include all types of furnaces with the different methods for firing the various fuels in use. I shall, however, cover briefly the various methods of firing metallurgical heating furnaces, and describe particularly two certain types of furnaces with which I am particularly acquainted. These furnaces use by-product coke oven gas as fuel, but conclusions can be drawn from the results of tests, that may be applicable to future development of furnaces using any type of fuel in order to obtain more efficient and better heating.

Selection of Fuels.

The choice of fuels for use in heating furnaces is governed by availability and cost. When natural gas was plentiful and cheap practically no other fuel was used, but with the growing scarcity of this fuel, operators have been forced by considerations of cost and even by law to substitute other fuels.

The gaseous fuels such as natural or by-product gas are ideal fuels for use in heating furnaces. They require the least amount of equipment; a gas main, regulator and burners with necessary valves make a complete installation. The varying demand of the furnace can readily be met with an increase or decrease in the supply of fuel, while the temperature of the furnace can be held at any point within the range required for heating steel. The most important factor governing the successful use of a gaseous fuel is the maintenance of a constant pressure on the burner valves. This can be accomplished by the installation of an automatic pressure regulator.

Liquid fuels such as by-product tar and fuel oil require additional equipment. A storage tank equipped with some means of heating the fuel, such as pipe coils filled with steam, a pump, pressure regulator and atomizing burners with the necessary piping and valves make up the usual installation. The atomizing burners may be of the pressure type or may require steam or compressed air, in which case a source of supply for the atomizing agent must be provided. As in the case of gaseous fuels, constant pressure for both fuel and atomizing agent are requisite for good operation of the furnace. The main reasons these fuels have not found broader use lies in the scarcity of by-product tar and the cost of fuel oil at the main steel mill centers.

Solid fuel in the form of coal has been used in many reverberatory heating furnaces. Originally, the firing was done by hand and the ashes removed by manual labor. The high labor cost in this country has forced the development of labor saving devices. The mechanical stoker has found ready application and a large number of furnaces are operated in this manner at present. The installation, aside from the stoker proper, requires the addition of coal and ash handling machinery, bins and in the case of forced draft stokers, the necessary fans and air ducts. It also precludes to a great extent the savings that can be obtained from recuperation of the air for combustion.

Another development in the application of coal as fuel for heating furnaces has been through the use of gas producers. By this method the preparation of the fuel is removed from the furnace and the heater has to deal with only a gaseous fuel. Only about 80 per cent of the heating value of the coal is realized in the producer gas, however, and with the rapidly rising cost of coal in this country it will become more and more difficult to justify this loss. There is a large increase in the initial cost of the furnace installation to provide the producers, building, coal and ash handling machinery, gas flues and steam lines. A general estimate of the cost can hardly be made, since much depends on the individual installation. The size of the producer plant, location with reference to furnaces served, number of furnaces to be operated from one producer plant and such items require that a separate study be made for each case. The cost of operating the producer plant, that is gasifying the coal, must be added to the fuel cost in any comparison of prices of various fuels.

In recent years powdered coal fired heating furnaces have found favor in many plants, particularly in France. A number of problems in its use will have to be overcome successfully before its adoption will become general. Removal of the ash from the products of combustion or provision for its free passage through the furnace must be provided in order to insure uniform heating of the steel. The intense flame with its consequent cutting action on the steel must be cared for, and the gain in efficiency due to preheating the air for combustion will increase this difficulty by causing a still more intense flame. A number of methods and systems for pulverizing, conveying and firing powdered coal are on the market, and if the various difficulties can be successfully overcome, material savings in fuel may be obtained.

*Paper read before the American Iron and Steel Institute, at New York, October 27, 1922.

†Fuel and Experimental Engineer, Carnegie Steel Company, Duquesne, Pa.

Generated on 2024-09-08 15:50 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

The application of electrical heating in metallurgical work is comparatively new. Furnaces using electrical heat for heat treatment of steel, either as castings or forgings, are successful and on account of the accuracy with which the desired temperature may be maintained and the freedom from oxidation, it is found that it pays to use the more expensive fuel for source of heat, electricity. It is doubtful if electricity will be used to heat steel in the form of blooms, slabs and billets made of ordinary steel, except in special localities where electricity is cheap and fuel is scarce and expensive. However, where steel is placed in a furnace hot and merely receives a soaking heat, as in the case of ingots in soaking pits, the amount of electric current required per ton of steel is small and it is probable that the saving due to freedom from oxidation or scale and from burnt steel will more than compensate for the cost of the electric current. Such electrically heated soaking pits have been designed, although they are not in operation at the present time.

The following table has been prepared to show the allowable price that can be paid for variuos fuels to be equivalent in heating value to natural gas at $0.30 per thousand cubic feet. The cost of preparing and firing the fuels has been added in arriving at the allowable price, but no allowance has been made for the efficiency obtained in the furnace itself. Also no charge for depreciation or interest on the initial investment has been made, since so much depends on the individual installation.

Unit	Fuel: Natural Gas 1,000 Cu. Ft.	By-Product Gas 1,000 Cu. Ft.	By-Product Tar 1 Gal.	Fuel Oil 1 Gal.	Coal as Producer Gas 1 Gross Ton
Btu. per unit delivered at heating furnace	950,000	496,000	156,000	137,600	24,192,000
Equivalent of 1,000 cu. ft. of natural gas	1,000	1,915	6.09	6.90	.03926
Cost of preparing per unit	00	00	$.00023	$.00023	$1.60
Cost of firing per unit	00	00	.005	.004	.....
Total cost of equivalent of 1,000 cu. ft. of natural gas	$.30	.30	.30	.30	.30
Cost above fuel of equivalent of 1,000 cu. ft. of natural gas	00	00	.0304	.0276	.0628
Allowable cost equivalent of 1,000 cu. ft. of natural gas	.30	.30	.2696	.2724	.2372
Allowable cost per unit to be equivalent to coal cost of 1,000 cu. ft, of natural gas	.30	.157	.044	.040	6.04

Types of Furnaces.

There are two main types of furnaces in use for heating blooms, slabs and billets, the continuous and the non-continuous. The latter is similar in construction to the Siemens open-hearth furnace, the direction of the gas flame across the hearth is periodically reversed and the furnace is usually equipped with regenerative checker chambers for preheating the air used for combustion. The blooms or slabs which this type of furnace usually heats are charged on the hearth of the furnace and remain in the one place till hot enough to roll. The continuous furnace is not reversed, the flame always traveling in the one direction, while the steel usually in the form of billets, passes through the furnace in the opposite direction. The cold billets enter the furnace at the coolest point and are pushed forward to the point of maximum temperature where they are discharged to the rolls. In the continuous furnace the billets lie tight together on the skids, forming a large steel plate on the floor of the furnace. Only the top of the billet is exposed so that all the heat required to bring the steel to rolling temperature must be absorbed by this surface. In the non-continuous furnace there is an open space between the blooms, so that three sides are available for directly absorbing the heat from the products of combustion or roof, while the fourth side is resting on the heated hearth of the furnace and absorbs from it a large amount of heat.

The time required for heating billets, slabs or blooms depends on the temperature of the heating medium, the surface of the steel exposed and the thickness of the steel. The temperature of the continuous furnace is at a maximum only at the discharge end and gradually decreases to the rear, while only one side of the billet is available for absorbing heat. In the non-continuous furnace the temperature is at the maximum throughout and three sides of the billet are available for absorbing heat. It is evident, therefore, that the same sized billet must remain longer in the continuous than in the non-continuous furnace. The dimensions of the non-continuous furnace do not affect directly the time of heating, but in the continuous furnace, with the rolling mill handling a given number of bars per hour, the length of the furnace fixes the time of heating. With everything else the same, the time of heating in a continuous furnace varies as the square of the thickness of the billet, so that a five-inch square billet requires four times as long as a two and one-half inch square billet. This means that for the larger sizes of billets long furnaces are required to give the capacity required by the rolling mill. For blooms and slabs the general practice so far has been to use non-continuous furnaces, but for 5 by 5 inch billets and smaller the continuous furnace proves very satisfactory.

Certain of the alloy and spring steels, if heated too rapidly, tend to crack, so that care must be used in bringing such billets up to rolling temperature. The continuous furnace fits this class of steel admirably since the billet enters a relatively cool part of the furnace and is gradually heated to the temperature required for rolling.

Non-Continuous Regeneration Furnace.

A sketch of a non-continuous regenerative furnace is shown in Fig. 1. The hearth which is 18 feet wide by 35 feet long has a silica bottom, made by fusing sand in thin layers until the proper thickness is reached.

A slight slope toward the rear of the furnace allows the slag which forms to drain through spouts into slag pots. The steel is charged and drawn through doors in the front by a charging machine. Four pots are provided at each end of the furnace, through which the gas with part of the air for combustion is admitted. The remaining air for combustion enters through a wide port opening between the roof and the top of the gas ports. Two regenerative checker chambers are provided at each end of the furnace, as producer gas was the fuel initially used and this gas was preheated

Generated on 2024-09-08 15:48 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

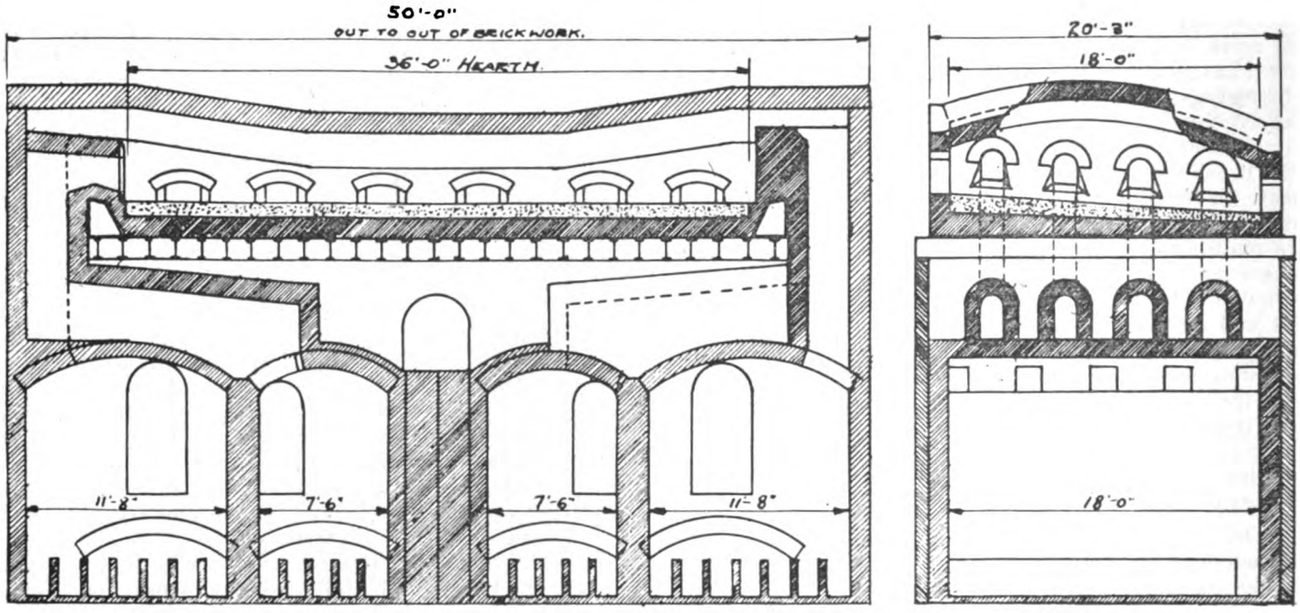


Fig. I—Non-Continuous Regenerative Heating Furnace.

as well as the air for combustion. The checker chambers are connected to the stack by flues containing valves and dampers, so arranged that the direction of the flow of the hot products of combustion across the hearth may be periodically reversed. In this manner the gas is first burned through one end of the furnace, while the waste gases leave at the opposite end, heating the checkers in their passage to the stack. The flow is then reversed, the gas is burned through the other end and the air for combustion is preheated in the checker chambers which have just received their heat from the waste gases.

Two of these furnaces serve one rolling mill. With one furnace containing steel heated and ready to roll, the first door is opened and the part of the hearth served by this door cleared of steel. Then the second door is started in the same manner, and while drawing the second door, the first is recharged. This is continued till all the hot steel has been drawn and the furnace refilled with cold blooms. The charging machine then moves to the second furnace and repeats the operation. By alternating the furnaces little time is lost waiting on hot steel. Blooms varying from 5 by 5 inches to 9½ by 11 inches are heated in this furnace.

Efficiency Tests of Non-Continuous Regenerative Furnaces.

Method of Testing: Efficiency tests conducted on the furnace just described were made in the following manner: The amount of by-product gas used as fuel was measured by a Wylie proportional meter, which was calibrated with a pitot tube for various rates of flow. The pressure of the gas was measured with a mercury U gage, the temperature with mercurial thermomenter, and samples were taken for chemical analysis from which the heating value was calculated. A record was kept of the number and size of blooms heated and the temperature of the steel leaving the furnace was measured by a Leeds & Northrup optical pyrometr. The steel entering the furnace was at atmospheric temperature. Analysis of the waste gases in the flues leading from the checker chambers to the stack were made with an Orsat apparatus. Four thermo-couples were installed, two at either end of the furnace, with one in each of the flues leading from the regenerative chambers to the stack. In this manner the temperature of the waste gases leaving each regenerative chamber was determined and the average of all readings used for calculating the stack loss. The temperature of the preheated air entering and of the waste gases leaving the furnace was obtained with an optical pyrometer sighted on the brick walls of the flues leading from the regenerative chambers to the ports, determinations being made on the air from each chamber. Readings were also taken of the furnace temperature with an optical pyrometer, and atmospheric temperature near the furnace with a mercurial thermometer. The barometric pressure was read during each test and the specific gravity of the gas checked periodically.

Readings of all instruments were taken every ten minutes during the test and samples of waste gas were analyzed every ten minutes.

The regular operation of the furnace consisted of a drawing and charging period followed by a heating period, which required that the starting and stopping point of the test be at the same point in the cycle in order that the gas supplied and the steel heated would bear the correct relation to each other.

Calculation of results: The following methods were employed in calculating the results shown in the following pages:

The heat absorbed by the steel was found from the weight of steel heated, the temperatures of the steel entering and leaving the furnace and the specific heat of steel which for these tests was taken as 0.166. The weight of steel was obtained from the number and weight of blooms entering the furnace. The heat supplied to the furnace was determined from the heat value of the fuel gas, as calculated from the chemical analysis and the number of cubic feet of gas burned reduced to standard condition of 2 deg. F. and 30 inches of mercury pressure.

The losses were calculated according to the usual engineering practice, the loss to radiation being taken as the difference between the heat supplied in the gas

Generated on 2024-09-08 15:49 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

and the sum of heat absorbed by the steel and all losses except radiation.

The efficiency of the furnace as shown is the ratio of the heat absorbed by the steel to the heat delivered in the gas. The efficiency of the regenerator was calculated by assuming that all the heat in the gases entering the regenerator was available for absorption by the air. The difference between the heat content of the gases entering and leaving the regenerator was assumed as the heat absorbed by the air. The efficiency shown is the ratio of the heat absorbed by the air to the sensible heat of gases entering the regenerator.

From the analysis of the waste gases a study was made of the infiltration of air at various points. The amount of excess air in the waste gases leaving the regenerator was first calculated. The air entering the furnace through the ports was calculated by a heat balance of the regenerator assuming no radiation. This assumption is partially true because the regenerators are entirely under ground and are therefore very thoroughly insulated. The difference between the amount of air entering the ports and the amount of air used for combustion with the excess as shown in the regenerator gases is the amount of air that infiltrated through the doors and openings in the furnace.

Discussion of Results: From the tabulated results it will be seen that the efficiencies varied from 36 to 41 per cent. It is interesting to note that with the highest efficiency the following conditions prevailed: the lowest rate of heating steel, the lowest gas consumption, the lowest radiation and the lowest stack loss, while the reverse conditions prevailed on the test having the lowest efficiency. It will be seen that the greater rate of heating is accompanied with greater furnace temperature and the corresponding greater heat losses.

Continuous Recuperative Furnace.

A sketch of a continuous billet heating furnace equipped with a recuperator for preheating the air for combustion is shown in Fig. 2. The billets enter through a side door in the upper end of the furnace, passing into the furnace on rollers, are pushed forward on the skids of the furnace by a set of arms which operate through the rear end wall and are discharged through a small door in the side wall at the other end of the furnace by a pusher bar driven by pinch rolls. The discharged door is in line with the first pass of the roughing rolls, so that the billet enters the rolls before being completely discharged from the furnace.

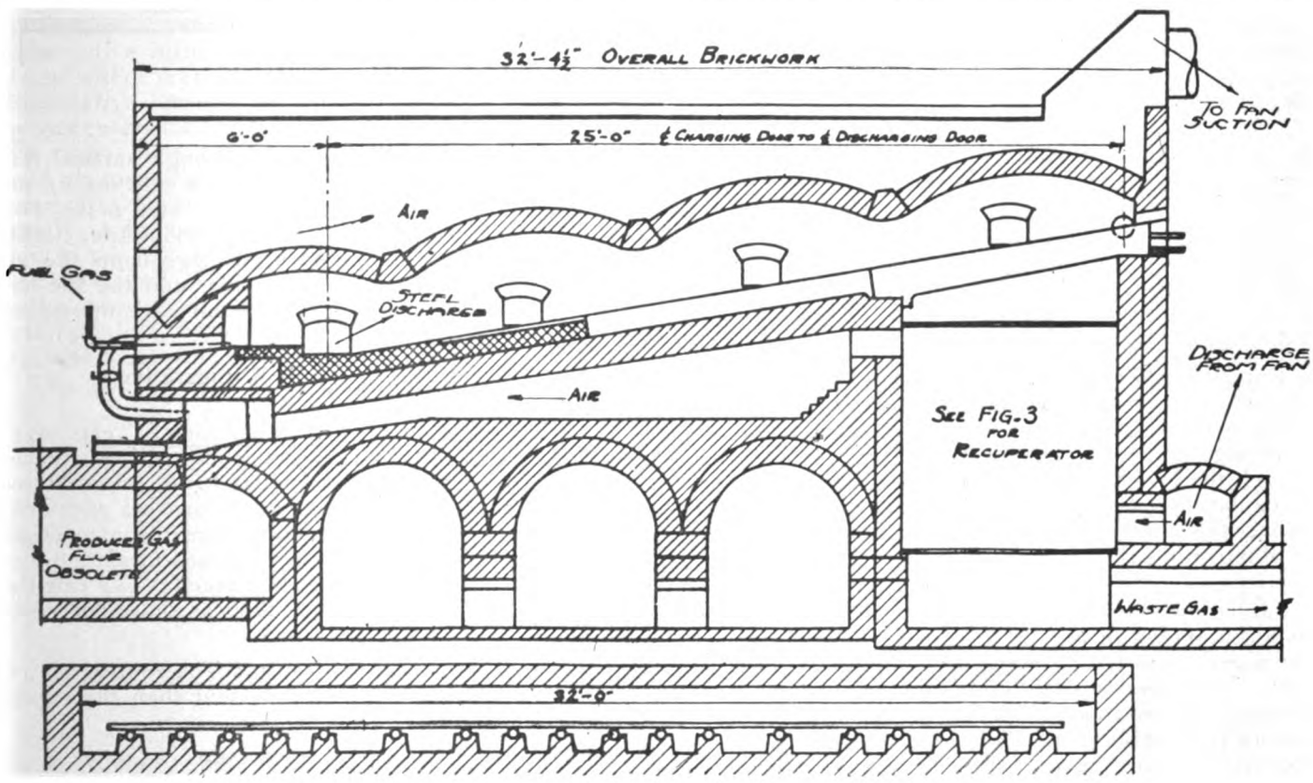


Fig. 2—Continuous Recuperative Heating Furnace.

This design is possible where only one furnace supplies a mill. If two or more furnaces are used the billets usually fall from the hearth through the end of the furnace, upon the rollers of the transfer table. This design necessitates having an opening in the end of the furnace extending the full width. The opening is partially closed by swinging doors, bars or pipes, but allows a large amount of cold air to pass into the combustion chamber at the point where the billets are being heated to their highest tempearture.

The roof consists of four arches thrown in the direction of travel of the steel. The skewbacks for these arches are supported by a water-cooled system of pipes hung by straps from steel beams which rest on the side walls of the furnace. The side walls extend three feet above the arch. Steel trays filled with sand are placed over the beams forming an air space over the roof.

Water-cooled skids are used to bridge the opening

Generated on 2024-09-08 15:45 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

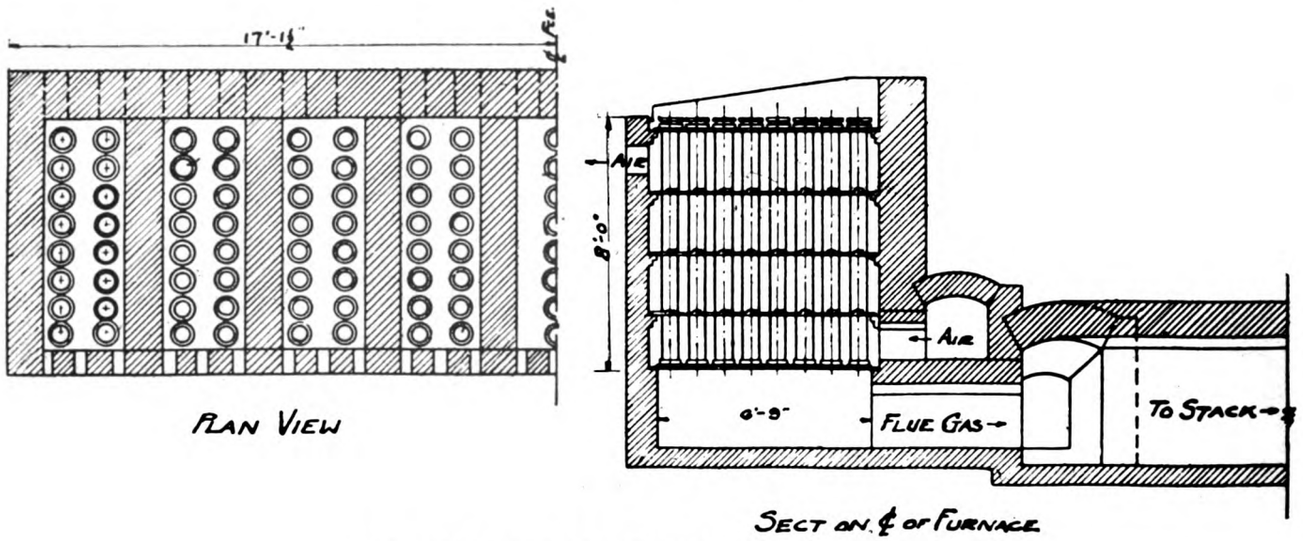


Fig. 3—Recuperator for continuous Heating Furnace.

into the recuperator chamber, but no water-cooling occurs beyond the point where the fire brick floor of the furnace commences.

Cast iron skids support the billets to within 3 feet of the discharge door where a magnesite brick bottom, built flush with the tops of the skids covers the floor of the hearth. The cast iron skids without water-cooling give excellent service.

Fifteen burners are provided across the end of the furnace. The burner consists of a cast iron return bend having a small gas pipe concentrically located in the upper leg, while the air for combustion is supplied through the lower leg which is provided with a butterfly regulating valve. Mixing of air and gas takes place beyond the nose of the gas pipe, the flame entering the combustion chamber through the ports of the furnace.

The recuperator for preheating the air used for combustion is shown in Fig. 3. It consists of vertical cast iron pipes supported by plates with additional baffling plates. The products of combustion pass downward through the pipes to a flue leading to the stack. The air used for combustion is partially heated by being drawn through the space between the roof of the furnace and the sand trays supported on the cross beams by a fan, which discharges through a flue into the recuperator chamber. The air passes upward on the outside of the cast iron pipes, receiving heat through the walls of the pipes. Leaving recuperator, the air passes under the floor of the furnace through ducts to the opposite end, where it enters the bottom leg of the cast iron burners. The furnace is used for heating from 1½ to 2½-inch square billets.

A second continuous billet heating furnace is shown in Fig. 4. This furnace has a flat roof which eliminates the water-cooling used on the skewbacks for the arched roof. It is also equipped with a brick recuperator. The downward passageways are square brick flues, while the air for combustion is baffled, in the manner shown, to make seven passes across the heated brick walls.

The brick recuperator has received a great deal of attention abroad and a number of special form tiles have been developed with which the recuperator is constructed. In one type, the recuperator chamber is located below the furnace. The air for combustion passes upward, by natural draft, through vertical rectangular flues, while the waste gases entering at the top travel through horizontal flues and make two passes across the outside of the air-carrying tile. Great care has been used to prevent leakage from the air passageways into the waste gas flues and the tile has been designed as thin as is consistent with the necessary strength.

Efficiency Tests of Continuous Recuperative Furnaces.

Method of Testing and Calculating: Tests were conducted on the two continuous recuperative furnaces just described in a manner similar to those conducted on the non-continuous regenerative furnaces with only the necessary changes due to difference in construction. The amount of cooling-water used was measured and the inlet and outlet temperatures noted. The calculations followed along the same lines as those described for the regenerative furnace.

General Discussion of Results: The continuous recuperative furnaces are more efficient than the regenerative furnaces as shown below:

EFFICIENCY OBTAINED

No. Furnace	No. 1 Run	No. 2 Run	No. 3 Run	Type of Furnace
2 Mill.....	62	63	58	Continuous Recuperative
5 Mill.....	38	41	37	Non-Continuous Regenerative
6 Mill.....	47	57	53	Continuous Recuperative

This higher efficiency is due to the method of operation of the continuous furnace; namely, the cold steel enters the furnace at one end and progresses slowly toward the other end, at which time it has become hot enough to roll.

The gases traveling in the opposite direction—from the hot to the cold end—are cooled by the steel and therefore leave the furnace chamber at a much lower temperature than the gases of the regenerative furnace. In the latter furnace all parts of the hearth are maintained at the same temperature.

TEMPERATURES OF GASES LEAVING FURNACE CHAMBER

Non-Continuous Regenerative	2001 deg. F.
Continuous Recuperative	1192 deg. F.

The principal heat losses of heating furnaces are the stack losses and radiation. The following table taken from the heat balances secured during the tests shows

Generated on 2024-09-08 15:48 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

the relative proportions of these losses and of the heat absorbed by the steel. For the amounts of heat in Btu. refer to Table A, giving data and results of tests:

HEAT BALANCE IN PER CENT

Furnace No.	Type	Per Test No.	Per cent Heat in Fuel Gas	Per cent Heat to Steel	Per cent Heat to Cooling Water	Per cent Heat in Stack	Per Heat Radiated
2	Continuous recuperative ...	1	100	62	1	20	17
2	Continuous recuperative ...	2	100	63	2	21	14
2	Continuous recuperative ...	3	100	58	1	20	21
5	Non-Continuous regenerative	1	100	38	..	27	35
5	Non-Continuous regenerative	2	100	41	..	27	32
5	Non-Continuous regenerative	3	100	37	..	31	32
6	Continuous recuperative ...	1	100	47	2	30	21
6	Continuous recuperative ...	2	100	57	2	28	13
6	Continuous recuperative ...	3	100	53	2	29	16

This table clearly shows the reason why the use of regenerative furnaces should be limited to only those places where it is impossible to apply the continuous recuperative furnace, for less than half of the heat in the gas enters the steel in the non-continuous regenerative type. The regenerative furnace does not lend itself to insulation to prevent radiation, because the temperature over the entire chamber is the same and usually so intense that if insulation were applied the limit of the refractories would be reached and the furnace destroyed. The continuous recuperative furnace, on the other hand, does lend itself to insulation to prevent radiation, because this furnace is comparatively cool and most of the radiating areas can be insulated.

The two continuous furnaces tested had different recuperators as before mentioned. The following table gives the losses in air pressure through the two types:

DROP IN AIR PRESSURE THROUGH RECUPERATORS, IN INCHES OF WATER

Furnace No.	Type of Recuperator	Run No. 1	Run No. 2	Run. No. 3
2	Brick	2.11	2.40	1.55
6	Cast Iron.....	1.18	1.38	1.41

The greater drop in air pressure through the brick recuperator is due mainly to the sharp turns around the ends of the baffles placed in the recuperator. The cast iron recuperator also has a distinct advantage over the brick recuperator in that its passages can be made of such shape and with surfaces smooth enough that the drop in air pressure through it will be less than can be secured in brick recuperators, where the passages in most cases must be made of rectangular cross section and have rough surfaces. Cast iron is also much better for conducting heat than fire brick.

In both series of tests on continuous recuperative furnaces the efficiencies were highest when the largest size billets were handled. The following table gives the size of billets, radiation loss and efficiency for the series of tests on the two recuperative furnaces:

Furnace No.	Test No.	Billet Size in Inches	Per cent Radiation Loss	Per cent Efficiency
2	1	3¼ x 3¼	16.48	62.18
2	2	3¼ x 3¼ and 2½ x 2½	14.54	63.07
2	3	2½ x 2½	20.84	58.29
6	1	2 x 2	20.74	47.30
6	2	2½ x 2½	13.18	57.41
6	3	½ x 2½	16.00	52.52

It will be noted that the series on the smallest size billets had the largest radiation loss. This may be due to improper operation or design. When operating with

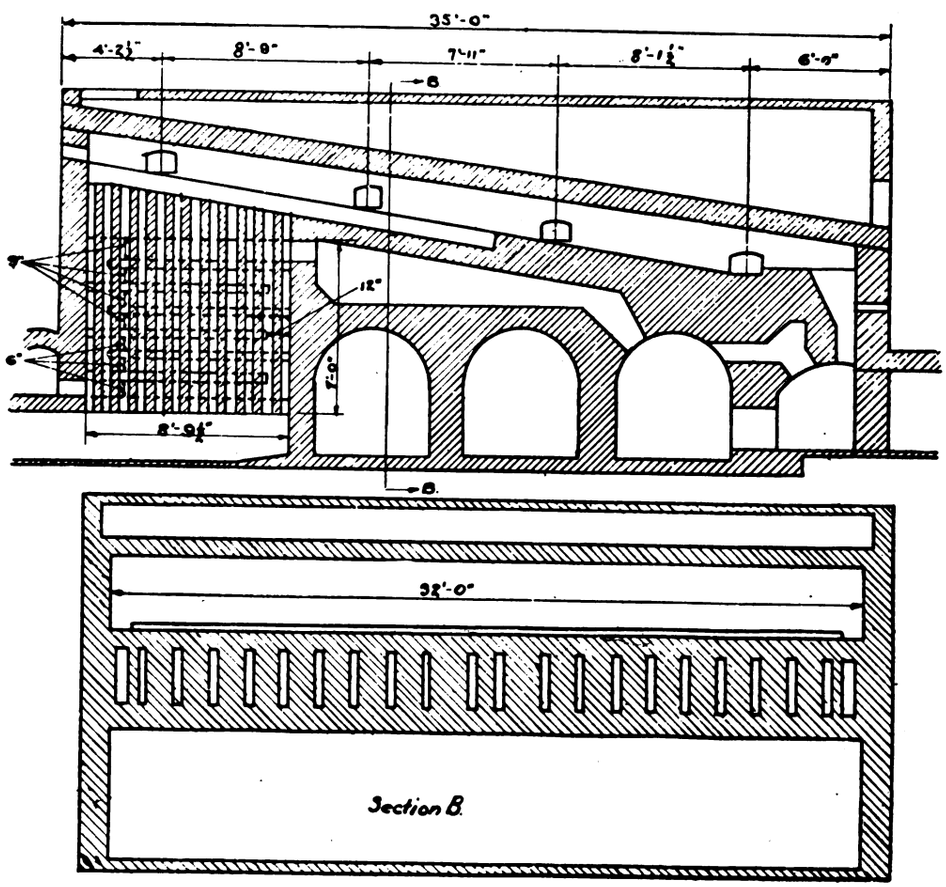


Fig. 4—Continuous Heating Furnace with brick recuperator.

Generated on 2024-09-08 15:48 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

the smaller size, the billets heat more quickly and are at rolling temperature before arriving at the discharging end. This causes a higher average temperature of steel, roof and side walls inside of the furnace, causing the greater radiation loss.

Conclusions and Recommendations: The data here shown was obtained, as mentioned before, on furnaces using by-product coke oven gas as fuel, but the following recommendations for future development will apply in the main to furnaces using any kind of fuel.

From the results shown in these tests, the development of heating furnaces should be along the lines of continuous recuperative furnaces unless some special reason makes it necessary to use another type. As has been shown the recommended type is superior to other types, as it is now built, and can be made even more efficient by development.

The furnace consists of a number of individual units, that is, roof, hearth, skids, burners, pusher, roof recuperator, main recuperator, discharge and charging mechanisms, meters and regulators, insulation and water-cooled devices. These will be taken up independently and recommendations tabulated.

A. Roof. The roof should be placed at such a height above the steel that the gases may wipe both surfaces and yet not cause too much resistance to their flow. A flat roof eliminates the necessity of water-cooling the arch supports. Some method of corrugation may be advisable to increase the surface for absorbing heat from the products of combustion. This would make available more heat for radiation from roof to steel and increase the rate of heat transfer.

B. Hearth. The hearth of the continuous furnace should be sloped from the charging end to the discharging end, care being exercised that the slope is not too great. This applies especially to long furnaces which are to handle large billets. The use of a basic lining for reversing furnaces would give a supply of basic cinder. This can be used in open-hearth furnaces to replace lump ore, and therefore deserves careful consideration.

C. Skids. Solid cast iron skids should be installed on the floor of the furnace, to eliminate the heat lost in cooling-water and to simplify construction.

D. Burners. A series of burners should be installed across the width of the furnace in order to secure a uniform temperature. The burners should be equipped with valves for the independent control of both fuel gas and air for combustion.

E. Regulators and Meters. Each furnace should be equipped with some means whereby the gas and air pressures on the burners may be automatically maintained constant. Each furnace should be equipped with an integrating and recording device which will accurately measure the amount of gas delivered to the furnace.

F. Pusher. A pusher for advancing the steel along the skids of the furnace should be provided which will give a uniform motion that can be regulated very closely, both in regard to distance and speed. This mechanism may be actuated by either a hydraulic cylinder or a reversing motor.

G. Roof Recuperator. The use of a roof recuperator should be limited to that section of the roof in which the refractory property of the brick will not permit it to be insulated.

H. Discharging and Charging Mechanism. The side discharge which was explained in the description of the continuous furnace is superior to the dropping end discharge from a fuel standpoint. It eliminates the loss of heat due to the exposure of a poorly insulated surface to radiation from the hottest zone of the furnace, as it is impossible to properly insulate the swinging door on account of its construction and the abuse it receives. The side discharge admits less cold air to the furnace chamber and a side charging mechanism prevents to a large extent the leakage of air into the furnace.

I. Main Recuperator. The use of metal in recuperator construction has certain advantages over brick. It has a greater heat transfer rate and is not as susceptible to cracking with the consequent air leakage. The possibility of a design with the use of pipes or tubes similar to water tube boilers looks very attractive.

The recuperator should be constructed so that it offers the least resistance to the flow of air and gas consistent with good heat transfer. The gas and air passages should be designed so as to give as nearly uniform velocities at all points as is possible. That is, the variations in the volume of gas and air due to their varying temperature should be considered. It may be advisable to have the air flow through three banks of tubes in series with the waste gases passing over the outside. The tubes should be staggered to give the maximum heat interchange.

The recuperator should be located in such a position that it would be easily accessible for inspection and repair. Placing the recuperator above the furnace instead of under ground should be very carefully considered. A better distribution of the waste gases both through the furnace and in the recuperator would be possible than is the case where the entrance to the recuperator is directly below the steel to be heated, since the gases must pass over the ends of the billets. Additional insulation would be required but no drainage water could collect in the bottom of the chamber or flues.

J. Insulation. Insulation should be used to prevent radiation as far as is possible without reaching the refractory limit of the fire brick and yet remain under the point where first cost would overbalance economy.

K. Water-Cooled Devices. Water-cooled parts should be avoided wherever possible, because they are hard to keep in repair, dissipate an appreciable amount of the total heat of the gas, and their elimination reduces the cost of supplying the cooling water.

L. Waste Heat Boilers. Several installations of waste heat boilers have been made in connection with heating furnaces. However, the development of the recuperator holds such possibilities that furnace efficiencies comparable to good boiler practice should be obtained. Future development, however, may show that in some cases of non-continuous regenerative furnaces the waste heat boiler may have a field.

It will be observed that heating furnaces have been brought to a fair degree of development. The efficiences obtained are not comparable to those of the best heat interchanging appliances, such as boilers and blast furnace hot blast stoves. With the rapidly increasing cost of fuel in this country, it becomes very important that all heat using appliances be made as efficient as possible, and concerted effort along the lines of recuperative furnaces should be productive.

Generated on 2024-09-08 15:46 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

Fluorspar and Its Uses*

A Description of the Mineral—Deposits in the United States and Foreign Countries—Its Uses In and Outside of the Steel Industry —Geological Features, Mining Methods and Equipment—Milling.

By G. H. JONES†

FLUORSPAR, a comparatively unknown non-metallic mineral of moderate cost, widely distributed geologically, but of commercial value only in a few places in the world, is of essential and economic importance to steel makers from the fact that 80 to 85 per cent of the world's production is used in basic open-hearth and electric furnaces as a flux and detergent, and there is no known substitute.

Fluorite, as it is technically known and chemically as calcium fluoride (CaF_2), consists of calcium and fluorine in the proportions of 51.1 and 48.9 respectively. It is of a glassy luster and is only slightly harder than calcite and may be scratched with a knife. It crushes easily and may be distinguished from calcite by its failure to effervesce with dilute hydrochloric acid. It crystallizes in the isometric system and is often found in cubical crystals. Its specific gravity is 3.2 and it weighs approximately 200 pounds per cubic foot. Its cleavage is perfect. Its melting point is about 1,650 deg. F. In color fluorspar ranges, according to purity, from a clear colorless to a slightly bluish glass-like substance through various brilliant shades, and much of it is quite opaque. The color has little significance chemically.

The deposits thus far exploited in the United States are in Arizona, Colorado, Illinois, Kentucky, New Hampshire, New Mexico, Tennessee and Utah. Dependable domestic production based upon existing market conditions can only be obtained by users east of the Missouri River, from the Illinois-Kentucky districts, the great size and purity of which indicate that for many years they will continue to be the main source of our supply. The tonnage may be divided between Illinois and Kentucky as 70 is to 30.

In England fluorspar occurs abundantly in the carboniferous limestone and associated shale of the Yoredale group, where it is found as the gangue of metalliferous veins. It is usually but not invariably associated with calcite, quartz and barytes. The principle producing localities are in Durham and Derbyshire. A large proportion of the fluorspar produced in England has been obtained by screenings from waste dumps from old lead mines. But in the last few years the demand has called for a greater production. Other sources, including mining, are helping to furnish an adequate domestic supply and some tonnage for export.

In Canada there are known deposits in Ontario, but they are negligible from a commercial standpoint and worthy only of passing notice. Some fluorspar is mined near Trail in British Columbia, but now finds a possible market among steel makers only on the Pacific Coast.

Germany has been an exporter for some years of high grade ground fluorspar, and is now prepared to furnish gravel for steel making from several mines, which have been opened under the stimulus of increased domestic demand and the possibility of exporting to the United States and other countries.

In Mexico, flourspar has been found in many places but has been mined commercially in only one, a large deposit located near Guadalcazar, in San Luis Potosi. Other deposits promise to become profitable, and one of green fluorite, in Zacatecas, has been worked to a small extent.

In the United States buyers of fluorspar in Colorado, Utah and the Pacific Coast will continue to secure their supply from the western and foreign producers, as the rates of freight from the Illinois-Kentucky fields are too high for successful competition.

Fluorspar, formerly largely a waste product of the gangue of lead mines and in a smaller amount of other metal mines, was used in smeltnig as long ago as 1529 (Agricola), and according to H. Foster Bain, fluorspar was first discovered in place in Illinois in 1839, when it was encountered in galena in sinking a well on the farm now the property of the Fairview Company. In 1842 spar was discovered in galena near the site of the present Rosiclare mine. From that time on mining appears to have been carried on more or less continuously, but shipments did not begin until the early seventies and since 1880 have been regularly reported. In 1891 only one or two mines were actually making shipments. The production of washed gravel spar commenced in the spring of 1894, although the demand for it by steel companies at that time was small. A limited tonnage of lump spar was produced and shipped four or five years earlier.

Its consumption runs evenly with the production of basic open-hearth steel ingots, and its production increases or decreases as the steel business is good or bad.

The demand for steel making is for a washed gravel, sized ¾-inch and under, of 85 per cent and over in calcium fluoride and not to exceed 5 per cent in silica, and free from sulphides, lead and zinc, the shipper being penalized according to an agreed percentage, varying with different buyers, for a lower calcium fluoride or a higher silica content than the percentages here given.

A properly equipped mine has its own laboratory and watches the analyses as they are made from the mill feed, mill run and car loading, and is therefore in a position to guarantee the user the analysis specified.

This brings to my mind the necessity for buyers to adopt standard specifications for fluorspar and I suggest that this be taken up with the American Society for Testing Materials in order to determine what anal-

*Paper read before the American Iron and Steel Institute, at New York, October 27, 1922.

†President, Hillside Fluor Spar Mines, Chicago, Ill.

Generated on 2024-09-08 15:45 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

ysis is best for steel makers and other users, presenting penalties for inferior quality, and a bonus for superior ones, as in the case of iron ore, bearing in mind that the analysis specified should be fair and reasonable and not increase the cost to the seller, or make it so difficult to produce as to lessen the supply.

The open-hearth melter would then know exactly what he had to work with. It is a common assumption that the melter throws in so much spar whether high or low in calcium fluoride or silica, but that is not the case as he uses only enough to bring about the reaction required, and in that way readily determines the grade employed. There should be no excuse for paying for, and paying freight on unnecessary impurities, and the value of fluorspar to the steel maker should be based upon the amount of calcium fluoride and the lack of silica at consumers' bins.

Calcite which practically represents the difference between calcium fluoride and silica and 100 per cent is lime, and therefore not injurious, but of some value in the furnace.

The modern fluorspar concentrating mills eliminate all impurities objectionable to the users such as lead, zinc and barium sulphides, and these impurities have only to be considered when buying foreign fluorspar, or that shipped from mines having no separating equipment.

From the heads of the operating departments of a large steel company, I have been given the following information:

The elimination of phosphorus and sulphur depends almost entirely upon the limestone, so in order to take care of the phosphorus and sulphur it is necessary at all times to have a highly basic fluid slag. Phosphorus is reduced at a low temperature while sulphur is reduced at a high temperature. In fact, most of the sulphur is reduced after the heat has been melted and the slag made fluid and the bath raised to higher temperature.

The limestone slag, immediately after the heat is melted, lies like a blanket upon the bath and to insure proper oxidizing conditions it is necessary to thin up the slag, and render it more fluid so that the metallic contents of the bath will come into more intimate contact with the oxidizing slag. It is the universal practice in this country to use fluorspar for this purpose. Fluorspar acts as a neutral reagent and does not affect the basicity of the slag. The increased fluidity not only allows for quicker elimination of impurities in the metal but allows the transference of heat from the fuel to the bath of metal in much quicker time.

Twenty years or more ago it was the general practice in most of the steel plants of this country to add fluorspar just before the furnace was ready for tapping. During later years, however, it has become the more general practice to add the fluorspar in the early stages of the working of the heat, not only to allow the slag time enough to function properly with regard to impurities in the metal, but to eliminate sulphur at higher temperature and to allow the furnaceman more opportunity to quickly raise the temperature of the bath in case it is necessary to tap the heat a little early.

In some steel making districts, particularly in the east, pig iron is apt to be high in phosphorus and low in manganese and it is the general practice where scrap is plentiful and cheap, to charge as little pig as possible. Iron of this character requires a high lime charge, due to the fact that the small pig iron charge with consequent decreased amount of silicon and manganese does not tend to create a fluid slag; therefore, large additions of fluorspar are necessary. High manganese pig iron increases the fluidity of the slag and, therefore, decreases the amount of fluorspar necessary for thinning out the slag. A low silica content in fluorspar is most desirable as a high silica content means additional limestone. The latter item is not desirable from a tonnage standpoint because a high limestone charge adds to the time of heat in the furnace with the subsequent reduction of tonnage.

The general practice in this country would indicate the average consumption of from eight to 10 pounds of fluorspar per ton of steel. This depends upon the character of pig iron, scrap, etc., used in the various districts. The use of alumina as a substitute for fluorspar is being advocated in some quarters but to date has not been proved up commercially.

No bad effects of the spar on the walls or roof of the open-hearth furnace have been known and it has been found as time goes on that open-hearth superintendents are increasing the amount of flourspar used per ton of steel melted.

Mr. H. M. Howe in "The Metallurgy of Steel" (1890) in summing up fluorspar says it appears to favor dephosphorization:

1. By liquifying the slag and enabling it to assimilate the lime present, part of which might otherwise remain unmolten and inert and thus rendering the slag effectively basic to it.

2. Probably by volatilizing silicon from the metal thus diminishing the formation of silica and thereby increasing the basicity of the slag.

3. In certain cases, for example, when the conditions are not strongly oxidizing, by volatilizing phosphorus as fluoride.

Dr. Richard Moldenke at the New York Institute meeting, February 19, 1922, claimed that basic hearth electric furnaces should be used in every new installation. To desulphurize rapidly and well, lime and fluorspar must be used in combination to form an active slag on the molten metal.

The Iron Age, April 6, 1922, under the heading of "Fluorspar in the Open-Hearth" reviews editorially an article from a German source previously printed in The Iron Age of March 23, 1922 to which I refer you, as follows:

"New light is thrown on the chemistry of basic open-hearth practice by an article from a German source in The Iron Age of March 23 on 'Fluorspar in Open-Hearth Practice.' It is important to American steel makers in view of the large tonnage of basic open-hearth steel made in this country. Fluorspar is used in almost every heat of such steel, but the common thinking as to its function has not gone beyond the thinning of the slag and the cutting of the lime.

"The German studies show that fluorspar does more than this. It is an effective agent, when properly used, in removing sulphur from the steel. Comparing nine heats without fluorspar and nine in which it was used, the writer shows that in the first set, with all other conditions the same, the average sulphur content of the finished steel was 0.08 per cent and in the second set sulphur was down to 0.05 per cent. The author controverts the theory that the desulphurization, when fluorspar is used, is brought about by the slag being thus rendered more basic, and he shows by actual re-

Generated on 2024-09-08 15:45 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

sults that the ratio of the oxygen of the bases to that of the acids was 1.7 without fluorspar and 1.30 when fluorspar was used, there being in the latter case a marked decrease in sulphur in the steel. The presence of too much sulphur in basic steel has been a matter of no small concern in this country, it being more difficult to remove this element than to remove phosphorus in basic practice."

Outside of the steel industry many uses, and growing ones, are found for fluorspar. The glass, ceramic and enameling trades, including enameled tile and brick, are the next largest users, and use the highest grade hand picked and ground spar. Then come perhaps the electrolytical smelting of lead and antimony and other non-ferrous and ferrous smelters. It is also commencing to regain the standing it once had among foundries, the demand from which is expected to steadily increase, as the benefits derived include the reduction of the coke necessary on account of the reduction of the number of pounds of fluxing material used. Cleaner castings are obtained on account of more fluid metal and greater freedom from slag, and stronger castings for the same reason. Less iron is lost in the slag and the slag is more liquid. Less work is required in cleaning and repairing the cupola and taking care of the dump, by reason of the liquid slag causing the cupola to clean itself more readily, and because this class of slag is brittle and hence breaks up more readily in cleaning away the dump.

Fluorspar is also the main component part of many special foundry fluxes. It is used in the manufacture of carbide; in the preparation of a cyanide for the extraction of gold; in the mixing of certain cement waterproofing compounds; in a limited way by some Portland cement manufacturers; by chemical works in the manufacture of hydrofluoric acid, and sodium fluoride, practically chemically pure spar being specified. Also in the extraction of aluminum from bauxite.

A word about sodium fluoride for preserving wood. Mr. George M. Hunt in charge of section of Wood Preservative Forest Products Laboratory of the United States Government writes: "The desirability of sodium fluoride as a wood preservative is practically established. One large coal mining company has been using sodium fluoride since 1915 for the treatment of its mine timbers in preference to either coal tar, creosote or zinc chloride.

The present consumption of zinc chloride for wood preservation is about 25,000 tons per year, and the use of creosote is somewhat in excess of this.

Sodium fluoride can be used in the same manner with the same apparatus and for the same wood preserving purposes as zinc chloride. Sodium fluoride is twice as toxic as zinc chloride, is much less corrosive, does not injure paint, can be shipped as a dry powder in slack cooperage, and if it were in adequate supply at a reasonable price could eventually largely supersede zinc chloride, and probably creosote to a great extent.

Wood treated with sodium fluoride is non-inflammable, hard to ignite, burning poorly, and easily extinguished. This is practically the same as with zinc chloride, whereas creosote burns freely with a black smoke.

Several European countries and especially Austria, are making extensive use of sodium fluoride in preservation of all kinds of wood work, such as warehouses, dwellings and other building construction. It is also used more or less as an insecticide.

Mr. Benedict Crowell in the Engineering and Mining Journal, January 21, 1922, made the statement which follows: It is not generally realized that the known fluorspar deposits of this country are very limited in extent. War stimulation failed to develop a single new ore body of consequence, that I know of. The increased supply in 1917 and 1918 came from the exhaustion of reserves at the principal mines, depletion of all old and newly located shallow deposits, working over old dumps, and salvaging the low grade ore left in the old workings of abandoned mines. Prices of $35 to $60 per ton justified extreme activity.

Only four producers in the Illinois-Kentucky district have railroad connections. The rest are compelled to haul the ore and supplies from four to 15 miles over dirt roads, that are almost impassable for five months of the year.

During the war period many new companies were organized to develop and operate fluorspar prospects. Practically all used up their capital and passed into history. Many of them never actually produced a car of ore.

Exhaustion of shallow deposits, the uncertainty and added cost of deeper mining, necessary exploration, and dead work are contributing factors which have tripled the cost of producing fluorspar. It has become a complicated, expensive and relatively deep mining proposition.

Mr. J. M. Blayney, president of the Fairview Fluorspar and Lead Company in The Iron Trade Review, February 9, 1922, says: "The fluorspar industry today bears little resemblance to that existing six years ago. Few branches of business have so changed in such a short span of years, and probably in no other does the consumer know so little about the source of supply.

"In the earlier years the smaller demand was easily satisfied principally by a few operators favorably located on the Rosiclare vein in Hardin county who were mining comparatively large bodies at shallow levels and at low cost. In those days the shaft was small, the equipment was crude, and the milling plants were easily and inexpensively constructed. The ore bodies were relatively wide and the ore was of good quality, carrying little waste. The milling methods were simple and labor was cheap.

"Of all the operations in the Kentucky field, only one producing mine has a railroad connection. Most of the others lie from three to 14 miles from the shipping point, and the mine product and supplies must be hauled by team over dirt roads wholly impassable for such use about five months of each year.

"It is the consensus of opinion of mining engineers familiar with the industry that fluorspar deposits cannot be determined with any reasonable assurance except by the sinking of shafts and the driving of drifts. Diamond drilling is practically useless for the purpose of blocking out ore bodies. This is due, first, to the frequent pinches, both lateral and perpendicular, and to the rapidly changing widths and erratic character of the deposits themselves. In the second place, the Rosiclare district is largely honeycombed with narrow fissures or slips containing fluorspar from a few inches to a foot in width, lying at various angles and wholly unconnected with any commercial deposits of fluorspar, rendering the reading of core results uncertain. Diamond drilling has been tried for many years in

Generated on 2024-09-08 15:46 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

the district by half a dozen different companies, but no commercial body of fluorspar has even been developed by its use. Expensive shafts have been sunk on the apparent indications of diamond drill cores and in each case have failed to develop ore bodies."

Production of fluorspar in the United States was first reported in 1883. Years of normal production are:

1883	4,000 tons
1892	12,250 tons
1900	18,450 tons
1905	57,385 tons
1910	69,427 tons
1915	136,941 tons
1920	186,778 tons

The largest shipments, due to previous war demands, were 263,817 tons in 1918 to which add 12,572 tons imported in that year.

In 1921 shipments dropped to 34,960 tons due to large stocks and depression in the steel business.

English production has averaged for the last eight years about 50,000 tons annually. Exact German production reports are not available, but indicate about 8,000 tons annually, and should show much larger for 1921 and 1922.

The highest average prices realized for fluorspar at mines including shipments made on old low-price contracts were:

1918	$20.72 per ton
1919	25.49 per ton
1920	25.26 per ton

Basic open-hearth steel production at five-year intervals shows:

1900	2,545,091 tons
1905	7,815,728 tons
1910	15,292,329 tons
1915	22,308,725 tons
1920	31,375,723 tons

As indicating the consumption of fluorspar for these years gravel fluorspar was produced in the United States as follows:

1910	52,013 tons
1915	114,151 tons
1920	154,786 tons

No records were kept of importations when fluorspar was on the free list, prior to August, 1909, but for subsequent years imports were as follows:

1910	42,488 tons (largest on record)
1915	7,167 tons
1920	24,612 tons

Of the 1920 imports England furnished 17,096 tons, Canada, 7,086 tons, chiefly from British Columbia, and Germany, 407 tons.

Fluorspar was on the free list until August, 1909, when a duty of $3.00 per ton went into effect. This was reduced to $1.50 per ton, October, 1913. The present duty of $5.60 per ton is in the new tariff of September, 1922.

Shipments are made in open or box cars, in bulk or in 125-pound bags or barrels, and in less than carloads in these packages.

A rough estimate shows consumption about as follows:

Steel ingots and castings	80 to 85%
Glass and enameling	7½ to 10%
Hydrofluoric acid	5 to 6%
Foundries	1 to 2%
Miscellaneous	2%

Geological Features.

The Illinois State Geological Survey (Bulletin No. 41, 1920) in co-operation with the United States Geological Survey has made a careful study of the geology of the fluorspar region in Illinois and has issued a very interesting and complete report covering its field work.

The rock formation consists of limestone, shales and sandstones of Devonian, Mississippian and Pennsylvanian age with massive limestone beds predominating, the uppermost series of these beds underlying the coal measures, dipping under them to the north and west.

Structurally the geology is very interesting as the rock beds have been bowed up to form an immense dome. The intrusion of igneous dikes and sills caused further rock movements and adjustments with differential settings of large blocks and the formation of large fissures and faults. These faults, planes and fissures furnished channels in which ore-bearing solutions traversed the strata and where conditions were favorable filled up the fissures with ore deposits containing fluorite, lead and zinc, with a calcite gangue. Not all fissures contain ore nor are all ore deposits in fissures, but it seems well established that the ore-bearing solutions used the fissures as channels for circulation.

The first mineral to be deposited in the fissures was calcite, and later changes in the character of the circulating waters and often a further series of rock movements caused the calcite to be redissolved and replaced by fluorite accompanied by lead and sometimes zinc.

As is often the case in many mining districts, there is in the Illinois fluorspar district, one especially notable vein or fissure system. This unusual vertical fissure vein is known as the Rosiclare vein which, with several parallel veins formed at the same time, has produced nearly all the fluorspar mined in Illinois. This vein has been traced for a length of nearly three miles and the underground workings on it total some 10,000 feet in length and it has been developed to a depth of 620 feet from the surface. The dip of this vein is to the west, but it is so slight as to be practically vertical.

The ore chutes on this fissure attain a maximum known width of about 22 feet with an average width of 6 to 8 feet. There are narrow spots or pinches alternating with good sized bodies of ore, as is usual in most fissure veins, and some ore chutes have been mined that measured over 1,000 feet long.

There is one fluorspar deposit, located near Cave-in-Rock, Illinois, which is unusual in that the fluorite has replaced a bed of limestone. Apparently the mineral-bearing waters circulated through the fissure which was closed by a bed of shale overlying a soft permeable limestone which has been replaced by fluorspar. In places this deposit is workable and several mining operations have been conducted on this bed which outcrops on the side of a hill, making open cut work feasible for moderate distances followed by underground mining from adits.

Three companies operate on the Rosiclare vein, namely the Rosiclare Lead and Fluor Spar Mining Company, The Fairview Fluorspar and Lead Company, and the Hillside Fluor Spar Mines.

Mining Methods.

The usual methods of developing the fluorspar deposits in the fissure veins is by means of vertical shafts and drifts in the ore at vertical intervals of 75 to 100

Generated on 2024-09-08 15:47 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

feet. The larger mines put down a three-compartment concreted shaft with two compartments for cages or skips and a pipe and ladder compartment. When in ore it is customary to drive the drifts the full width of the ore and 12 to 14 feet high so that the necessary head room for setting timbers is secured.

Hitches are cut in the foot wall and heavy stulls are set across to the hanging wall, spaced about six-feet centers, the head of the stull being several feet higher than the foot, depending upon the width of the drift. These stulls are usually set with the heel or hitch end about five feet above the tram tracks and chutes for drawing ore are then built between alternate pairs of stulls.

The stulls are then covered with poles or split lagging and stoping begins by shooting down the ore upon the timbers and drawing it off through chutes into the tram cars. Enough ore for the miners to stand on and reach the back is held in the stopes, so that when a stope is beaten out to the level above it is practically full of broken ore, which amounts to about one-half of the ore originally in place in the solid.

Mine Equipment.

As none of the fluorspar mines are over 650 feet deep the hoisting equipment required is not large.

Sinking is done with the jackhammer type of drill, drifting and crosscutting is generally done with a mounted type machine, sometimes with a jackhammer where the ground is not too hard and a Waugh turbo type where more power is needed. Stoping is all done with air feed hand rotated stoping machines.

Pumping equipment is of great importance as the mines are wet. Under normal conditions the Fairview Company pumps about 1,500 gallons per minute and the Rosiclare Company about 700 gallons per minute, but in times of high water in the Ohio River the flow of water increases to double these figures.

Both of these mines are deeper than the Hillside mine which is mining in drained territory and has no water to speak of.

Milling.

To produce the commercial grades of spar demanded by the market it is necessary to mill the run of mine ore.

The Bureau of Mines has completed its fluorspar investigation of this year and says: "The importance of fluorspar in the steel and ceramic industries is so great and accurate information on methods of mining, milling and utilization, and on costs of production of fluorspar is so lacking that it has been considered advisable by the Bureau of Mines to investigate all phases of the fluorspar industry in the United States. At the request of and in company with several Eastern fluorspar producers, examination has been made of the principal fluorspar deposits of the Western States. This examination was followed by an intensive study of the producing mines in Illinois and Kentucky. It was found that most of the deposits of the far Western States were small and could not be relied on to produce such surplus over the needs of the Western States. Costs of production in the Illinois-Kentucky field have increased greatly owing to the increasing depth of the principal mines, the large amount of water that must be pumped and the increased cost of labor and supplies. A report of all phases of the fluorspar industry is in preparation."

Notwithstanding the large existing demand for fluorspar under normal conditions, which is constantly increasing, owing to the general increase in business and from new uses found for it, I feel it is not necessary that a substitute should be found, as with an increase in price, old mines and prospects in the Illinois-Kentucky field would be worked again as soon as a market price justified.

The same condition would again bring spar to the Eastern users from Colorado and New Mexico and importations from England and Germany would make up the deficiency, if any.

At succeeding levels of higher prices more and more production would come in until the demand was satisfied. An advance of a few or several dollars per ton would not be burdensome. Five dollars per ton would not be burdensome. Five dollars per ton would mean only 2½ cents per ton additional cost for steel ingots.

I think I am justified in saying that if necessary to insure an adequate supply the leading miners of florspar, if approached in the right spirit, with their knowledge of mining, with ample capital and expert engineering departments, would undertake necessary development work in the outlying districts provided the owners of prospects or local capital could not do so.

ALUMINUM INVESTIGATIONS OF THE BUREAN OF MINES

The investigation of cracks in aluminum alloy castings, conducted by Robert J. Anderson, metallurgist at the Pittsburgh, Pa., experiment station of the Bureau of Mines, has been finished in part, and a preliminary report issued. A method has been devised for the direct determination of aluminum in aluminum and aluminum alloys and also for aluminum oxide in these materials, and a report was issued.

SYNTHETIC CAST IRON

As is well known, pig iron is not produced on the Pacific Coast at the present time in sufficient quantities to meet the demand for iron of such grades as are required for foundry purposes. As a result, foundry iron is costly, due to high freight rates on eastern iron that is brought in and to the high cost of coke suitable for use in the cupola. On the other hand, considerable steel scrap is to be had, and, for that reason, attention has been recently given by the members of the Electrometallurgical Section of the Northwest Station of the Bureau of Mines at Seattle, to the problem of determining the best conditions for the production of cast iron by melting scrap steel in the electric furnace. These conditions were established by numerous experiments conducted in a laboratory furnace holding 300 lbs. of metal.

Later on these conditions were applied in a local foundry with excellent results. Low-grade miscellaneous steel scrap was melted and carburized in a 3,000-lb., direct arc, 3-phase electric furnace and the resultant metal discharged into the pouring ladle and then into the molds for the miscellaneous grey iron castings which made up the normal output of the foundry. The carbon and silicon content of the product was under control at all times and the furnace operator had no difficulty in producing the grade of iron required. Satisfactory castings were made with the normal consumption of power and electrodes.

Generated on 2024-09-08 15:46 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

Bases of Modern Blast Furnace Practice

Outline of Bases Upon Which Modern Blast Furnace Practice Has Been Built Up—Shows How Adoption of These Methods Leads to a Desirable Improvement Both Regarding Economy and Output.

By A. K. REESE*

PART II

IN the sense in which furnace design bears upon the purpose of this paper it refers not to the structural detail of the furnace as a whole, but to that portion only in which the metallurgical operations take place; that is, the furnace proper, the interior space, the design of which is technically known as the "lines of the furnace."

The terms usually used to describe the lines of a blast furnace divide it into a number of sections, namely, the hearth or crucible, which is cylindrical; the bosh, an inverted truncated cone; the shaft, an upright truncated cone; and the throat—in modern furnaces usually cylindrical—extending from the top of the shaft to the top of the furnace.

The principal dimensions of these sections consist of heights, diameters, the acute angle of the bosh wall to the horizontal, and the batter of the shaft wall to the vertical. Each of these dimensions has a very important bearing upon all the others, and their relation to each other is of the first importance as a factor in modern blast furnace practice; for although they may vary somewhat in their relation, the variations are limited to conform to certain principles, the height of the furnace and hearth diameter being the dimensions which control all the others.

Under this heading—Furnace Design—the author proposes to outline and discuss these principles, and to enunciate as a general law the principle that *the output capacity of a blast furnace (with any particular set of raw materials) is in proportion to the effective bosh area.* The nucleus of this law is the word *effective,* for as will be later shown the maximum effective bosh area is dependent upon the various factors which constitute the principles of modern blast furnace practice.

Modern development in blast furnace design has established the following essentials. A shaft batter of 1 in 13.5 to 15, the low bosh, the large hearth diameter, and the deep bosh angle—all of which are, of course, comparative terms in their relation to similar features in the older designs.

In a figure showing two furnaces, "A" and "B" of pre-modern lines (extreme cases have been chosen in order to emphasize the principles under discussion), and showing two furnaces, "C" and "D" of modern lines, the tendency is further to increase the hearth diameter, and a furnace is now in successful operation with a hearth diameter of 20 ft. 9 in., but in this direction it is sufficient for the present purpose to avoid the extremes.

Throat and Stack.—The upper section of the furnace or throat is, as above mentioned, usually cylindrical in shape and extends to from 20 ft. to 25 ft. below the furnace top or 12 ft. to 17 ft. below the stock line, the highest point to which the furnace may be filled. The adoption of the cylindrical throat is primarily in order to obtain the desired batter to the shaft walls, although it also has a bearing upon regularity of distribution by presenting to the charged materials an area of the same dimensions for the varying positions of the materials in the throat due to their constant movement. The latter point, however, is not of great importance in the modern furnace plant as the charging appliances are usually, or should be, of ample capacity to keep the furnace fully charged at the highest rate of driving.

Within the distance to which the cylindrical throat extends the condition of the materials is such that there is no tendency for them to adhere to the walls or to hang through jamming, or arching, as they are in a "dry" condition, both as to moisture and pastiness, and their expansion through increase in temperature is not yet sufficient to require increased space for their accommodation so as to avoid the danger of restricting free movement. Below this point, however, temperature increase becomes much more rapid and reactions much more intense. In this alteration in condition and temperature, which is progressive as the materials descend, more space accommodation is required for free movement, more particularly because to expansion is added the semi-pasty condition, and the increased density of the mass through the increasing load bearing down upon it from the increasing weight of superimposed materials. It is also probable that the question of carbon deposition enters into the necessity of greater space accommodation as the materials descend into the hotter and more active regions of the furnace. Hence the necessity for the expanding batter to the shaft walls. It would also seem obvious that the more rapid the descent of the materials into and through these zones (faster driving), the greater must be the increase in space accommodation. In the older furnace designs, with slower driving, shaft batters as low as 1 in 26, and possibly less, were in use. In modern practice it has been found necessary to increase this batter to 1 in 14, or thereabouts. The principles involved in this feature of modern blast furnace design are of the greatest importance, and probably explain, in part at least, why many furnace managers have failed in their attempts to apply fast driving to furnaces with lower shaft batter.

To revert for a moment to throat diameter, there are in this feature several opposing conditions to consider. The lower the velocity of the gases as they leave the furnace top, the lower the loss from flue dust carried over with them. The largest possible throat diameter is, therefore, desirable for this reason. On the other hand, the extent to which this feature may be provided for is limited by the question of distribution, both of the mate-

*Paper presented at British Iron and Steel Institute, autumn meeting, September, 1922.

Generated on 2024-09-08 16:14 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

rials charged into the top and the ascending gases, as regards the most uniform action of the latter over the whole cross-section of the former. The throat diameter is also limited by the required shaft batter, and the bosh diameter and height. Sacrifices must, therefore, be made in one direction or the other, and as the question of losses by flue dust is largely affected by regularity of stock movement, features tending to the latter should have first consideration. Throat diameters are, therefore, restricted in modern furnaces of 85 to 95 feet in height to from 15 to 17 feet, the controlling factors being the other dimensions such as hearth diameter, bosh diameter, and height.

The Low Bosh.—The low bosh was the direct outcome of attempts to increase blast furnace outputs by increasing the volume of blast blown per minute. These attempts with the old high bosh furnaces resulted in seriously increased furnace irregularities, the reason for which became apparent from the study of the altered conditions brought about in the furnace through the more rapid driving, and the troubles experienced. With the much more rapidly descending materials it was found necessary that the contracting part of the furnace, that is, the top of the bosh, should begin below the upper limit of the zone of fusion in order to prevent the pasty materials just above the zone of fusion entering the contracting area, where they would be subjected to a squeezing action as a result of the resistance of the bosh walls, and the weight of the superimposed materials, with the consequent tendency to pack and cause hanging and the formation of scaffolds on the upper bosh walls.

The continued lowering of the top of the bosh followed therefore the continued attempts at faster rates of driving for larger outputs, until in modern practice a bosh height for 85 to 95 ft. furnaces, of 10 to 12 ft. above the top of the crucible, has been adopted as compared with as much as 30 ft. in the old design. While it is true that no one would build a furnace with a 30-ft. high bosh today, there are furnaces in operation of recent design with boshes 16 to 18 ft. or even higher. Any attempt to rapidly drive such furnaces is sure to result in increased irregularity and consequent failure. The basis of this principle—the low bosh—is, therefore, that the furnace be so designed, as regards bosh height, that the expanding portion of the furnace, that is, the shaft, shall continue to a point slightly below the beginning of the melting zone, so that no pasty materials shall enter the contracting portion at the top of the bosh. In actual practice many, in fact most, modern furnaces are designed with a cylindrical section from 5 to 8 ft. in height between the lower limit of the expanding shaft and the upper limit of the contracting bosh. This section has no justification from the standpoint of any principles involved in its adoption, except that it fills up with brickwork the angular space at the junction of the bosh and shaft, which to a degree may be considered "dead space," and renders less abrupt the transition from the expanding shaft to the contracting bosh, but is rather the result of necessity in order to obtain the desired relation between other features such as shaft batter, throat diameter, and bosh diameter height.

The bosh diameters, for what may be called full-sized blast furnaces, that is from 85 to 95 ft. high, are usually from 20 to 23 ft. with a bosh angle of about 80 deg., while in pre-modern design this angle was anything from 68 deg. or less to 74 deg. The latter feature is the result of the progressive increase in hearth diameters, and, as the author will endeavor to show further on, these two features, the steep bosh angle and the large hearth, are concomitant, and their evolution the result of efforts to overcome irregularities through the failure of earlier designs (with the flatter bosh and smaller open hearth diameter) to bring into operation the maximum effective bosh area, which is, of course, the full bosh area.

The Hearth or Crucible.—In the modern full-sized furnaces hearth diameters are normally from 16 to 18 ft., although, as has already been mentioned, in one instance this dimension has reached 20 ft. 9 in. At present, however, the latter may be taken as an extreme, and it remains to be seen whether hearths of this size are likely to be generally adopted. In the process of evolutionary experiment it is often necessary to overreach the maximum in order to ascertain what it really is.

The hearth diameter of a blast furnace would seem, at first sight, to be the determining factor for its output capacity, and, in the sense that it is the starting point in the design, and, with the bosh angle and bosh height now generally adopted in modern design, practically determines the bosh diameter, it is so, but in the sense that the hearth diameter, together with the low bosh and steep bosh angle, are merely means for making effective the maximum bosh area it is not really the determining factor, which is the bosh diameter. The hearth, or more properly the crucible, is the receptacle for receiving and storing from cast to cast the molten materials, while the bosh area is the active area in which the molten materials are produced as such, and the proportion of that area which is in active operation is the determining factor as to the quantity of molten materials available for collection in the crucible.

In all previous references to the various dimensions of the modern blast furnace, and the principles which have led to their adoption, it is, of course, assumed that in the operation of the furnace the volume of blast is in keeping with the size of the furnace, and is such as will provide the operating conditions upon which those principles are based. In modern practice the volume of blast blown is normally from 40,000 to 50,000 cu. ft. of free air per minute delivered from engines capable of delivering these volumes against pressures, or rather resistances, up to 25 or 30 lbs. per sq. in., to provide ample reserve power for conditions causing abnormally high pressures. Normal working pressures are usually between 15 and 20 lbs.

Effective Bosh Area.—This term, used several times in the foregoing, is, the author believes, a new one in blast furnace nomenclature, but it is one which has a meaning of the first importance in blast furnace operations.

Heretofore it was enunciated as a general law that "the output capacity of a blast furnace, with any particular set of raw materials, is in proportion to its *effective* bosh area."

Before discussing this proposition it is necessary to define:

1. What is the "effective bosh area"? and to consider
2. What are the factors which control or determine the effective bosh area?
3. What bearing have these factors (through their determination of the effective bosh area) upon the output capacity of the furnace?

1. The effective bosh area is that portion of the full horizontal bosh area at its maximum diameter which is in normal activity under the conditions of operation of the furnace.

Generated on 2024-09-08 16:12 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

2. The factors which control or determine the effective bosh area are those which are under discussion in this paper, namely, the condition of the materials charged, the furnace lines, and the volume of blast blown per minute in relation to the size of the furnace.

3. The bearing these factors have upon the output capacity of the furnace is that they determine the area of activity in the melting zone.

The whole trend of evolution in blast furnace practice has been in attempts to devise means of increasing output capacity consistent, of course, with quality and economy, and the degree to which these attempts have been successful in modern practice has been due to the influence the factors in that practice, as described in this paper, have had in increasing the ratio of effective bosh area to the maximum or designed bosh area of the furnace, or to put it in simple terms, *to keeping the walls clean.* It is, therefore, conversely true that the effective bosh area of blast furnaces, where the factors upon which modern practice is based have not been adopted, or which are not operated in conformity with its principles, is less than the maximum or designed bosh area.

As has been described under Preparation of Materials, the direct tendency of lack of such preparation is towards restriction of active area in the furnace. Under furnace design the tendency of the high bosh and the low stack batter is shown to be towards restriction of active area in the furnace. Equally the tendency of the small hearth and flat bosh angle is towards restriction of effective bosh area, owing to the removal of the area at and adjacent to the top of the bosh near the walls too far horizontally from the upward moving gases, with the consequent tendency for accumulation of torpid or stationary materials in that area.

As previously described, for a furnace of a given size, insufficient blast volume to ensure equal activity throughout the whole cross-section at every altitude tends to the production of inactive areas owing to the impossibility of providing perfect uniformity of materials. The greater this lack of uniformity, the greater this tendency. The under blowing of a blast furnace is one of the most fruitful causes of reduction of effective bosh area, with outputs far below maximum output capacity.

The tendency of a blast furnace is to adjust its active areas to the volume of blast supplied to it. This tendency is in strong evidence where furnaces which have been blown for a considerable period with comparatively small blast volume, have been suddenly and too quickly supplied with a considerably increased volume. Operators who have made this experiment will doubtless recall the difficulties they have experienced through irregular working. The author knows of cases where, although the furnace size was quite suitable to the increased blast volume, the attempt has been abandoned through the conclusion that conditions were not suitable to faster driving, whereas a little persistence would probably have overcome the difficulties met with by the walls gradually clearing, and then furnace thus adjusting itself to the larger volume.

It is, of course, true that many blast furnaces in operation today are not adaptable to modern practice in its fullest sense. One or more of the necessary factors are lacking, and, as the author has attempted to show, each of these factors is so dependent upon the others that they must all be present for its full application. Among them, however, there is one, preparation of materials, which, if adopted alone, would provide conditions which would render possible the partial application of others with decided improvement in results, and tend to remove many of the difficulties now experienced.

Auxiliary Equipment.

Under this heading it is not intended to enter into, nor does the purpose of this paper call for, a detailed discussion of the many units comprising the auxiliary equipment of a modern blast furnace. There are, of course, certain units which are essential to the operation of any blast furnace. Where, for the purpose of emphasizing the requirements of modern blast furnace practice, it is necessary to discuss the modern features of these units they will be specifically referred to. There are also certain units which, while not essential to blast furnace operation in general, are essentials, from the standpoint of economical operation, to modern practice. These will be discussed in more detail, but only so far as the principles involved in their adoption are concerned.

The auxiliary equipment, or plant required for the operation of a blast furnace, may be divided into four sections:

1. The Power Plant.
2. The Blast Heating Plant.
3. The Raw Material Supply Plant.
4. The Output Disposal Plant.

Equipment falling under one or other of these sections is essential to the operation of every blast furnace (excepting, of course, a cold blast furnace which need not be considered here). In modern practice, however, there are certain features in the details of the plant required, bearing upon the method and economy of operation, which are essential to the full adoption of that practice.

1. The term *Power Plant,* which is used here in its most comprehensive sense, covers all apparatus for producing and utilizing the power required for sustaining the blast furnace operations. The principal among these are the boiler plant, the blowing engine plant, the electric generating plant, the water-pumping plant, and, in some cases, the hydraulic power and compressed air plant(and it might be added the dry blast plant). With regard to most of these items, it need only be said that they should be of the most modern, simple, and economical type, with ample reserve of power and capacity, in order to minimize those costly furnace stoppages which are otherwise likely to occur through mechanical failures, or interference with normal operation through lack of efficiency. In other respects they do not, with the exception of the blowing engines, bear directly upon the principles of modern blast furnace practice. In regard to blowing-engine capacity, and—in one particular feature—to turbo blowers, there is a point which it is important to emphasize. As previously stated, the volume of air required for the normal operation of a full-sized modern blast furnace is from 40,000 to 50,000 cubic feet of air per minute. It is important that this air should be delivered in as continuous a flow—that is as free from pulsations—as possible.

With reciprocating engines, the speed and number of blowing cylinders should be as great as possible consistent with engine safety and efficiency, and the range of volume delivered, with a fair degree of economy, as wide as possible. The engine should also be designed to deliver their maximum volume against pressures up to 25 to 30 lbs. per square inch with steam pressure or gas of quality at least 20 per cent below the normal, in order to provide for those abnormal conditions to which every blast furnace is liable. As regularity in air volume de-

Generated on 2024-09-08 15:49 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

livery is an essential of modern blast furnace practice, every blowing engine should be equipped with an efficient governing device.

As above mentioned, the centrifugal or turbo blower is widely used, and is rapidly growing in favor for blast furnace work. Well designed blowers of this type have a number of advantages over the reciprocating type. They are simpler in design. Per unit of capacity they are lighter in weight, require less floor space, less massive foundations, and are lower in first cost. They have fewer moving parts, have no losses through reversal of motion, are lower in cost of maintenance and repairs, require less attention in operation, and are much easier and less costly to lubricate. They have the advantage of giving a continuous flow of blast delivery, being entirely free from the pulsations in delivery, within their rated capacity, characteristic of the reciprocating type. There is however one feature in the turbo blower as compared with the reciprocating blower which must be specially provided for to ensure its suitability for modern blast furnace practice. As above stated, regularity or constancy of the volume of free air per minute, required by the furnace operator for the time being, is an essential of that practice. This volume must not materially vary or be affected by the more or less varying resistance, commonly called pressure, on the delivery side of the blower, due to the varying furnace conditions. In reciprocating blowers this requirement offers no difficulty, as regularity of the volume delivered is assured by regularity in engine revolutions, whatever the resistance, within the limits of the capacity of the blower. In the turbo blower, however, the volume delivered varies both with the engine revolutions and the resistance on the delivery side. The turbo blower, therefore, requires for its satisfactory application to modern blast furnace practice a special type of governing or controlling device in order to assure the delivery of a constant volume of blast per minute against the varying resistance offered by the varying furnace conditions, that is, a volume controller. For many years this feature in the turbo blower was a serious drawback, notwithstanding its many other advantages, to its adoption for blast furnaces. Its general adoption and growing use in recent years is directly due to this difficulty having been successfully solved through the design and application of an efficient volume regulator.

2. *The Blast Heating Plant* consists essentially of the hot blast stoves and their connections, for receiving cold blast from the blowers and waste gases from the furnace, and for delivering hot blast to the furnace and consumed gases to the atmosphere. Under this heading should be included another installation which, while not essential to blast furnace operation in general, is from the standpoint of economy an essential part of modern blast furnace equipment. This is the gas cleaning plant, or rather, a rough gas cleaning plant as distinct from the plant required for the high degree of gas cleaning necessary for use in gas engines.

The advantages and economies obtainable by the use of clean gas as compared with uncleaned gas are many and of very considerable importance, and far outweigh the cost of installation, operation, and upkeep, etc.

Though this question has already been fully discussed by various writers, a number of these advantages, some of which also apply to the boiler plant, are enumerated as follows:

(1) A much higher thermal efficiency of the gas is obtained through more perfect combustion, by better control of air and gas mixture, and the elimination of fume and other heat absorbing solid matter, with the consequent increase in the heat units available for absorption by the stove checker bricks and boiler flues.

(2) The saving of the labor constantly required for cleaning stoves and boiler flues.

(3) The saving of labor and materials required for repairs to stoves necessitated by the fluxing effect of the solid matter in uncleaned gas on the brickwork.

(4) The much longer life of stove linings through the absence of these destructive effects of uncleaned gas.

(5) The much greater time service per stove—and per boiler—through the elimination of lost time for cleaning and repairs.

(6) The much greater possible heating surface per unit of stove volume through the use of smaller checker openings, and the higher efficiency thus obtainable.

(7) The greater regularity in blast furnace temperatures obtainable through the maintenance of a higher average stove efficiency.

(8) The hot blast being practically free from abrasive dust there is an absence of its cutting (sand blast) action upon the linings of the hot blast connections and of the iron and steel fittings where blast leaks are liable to occur.

The very large volumes of blast used in modern blast furnace practice naturally necessitate stoves of much greater heating surface than is required in the older practice. The modern hot blast stove is, therefore, constructed with a heating surface of 70,000 to 85,000 sq. ft.; checker openings are from 3 in. to 4 in. in diameter or square, enclosed in a shell 20 to 22 ft. in diameter and from 95 to 110 ft. in height. There are usually four stoves per furnace, though in some cases seven stoves are provided for two furnaces, one being arranged so that it may be used on either furnace. This is open to the objection that the two furnaces may at times both need the extra stove to the probable disadvantage of one. Each furnace should have its own complete equipment when both are in operation. The stove shells and their fittings and connections must be of considerably greater strength than in the older constructions to withstand the higher pressures they are subject to, and the latter of ample area to accommodate freely the large volume of air and gas passing through them.

A small but important feature in modern blast furnace equipment is the blast temperature regulating pipe, which consists of a connection between the cold and hot blast mains. The purpose of this connection is for admitting cold blast direct into the hot blast main to enable the regulation of the blast temperature, usually downward, when required. The cold blast connection may be made at any convenient point in the cold blast main, but the connection into the hot blast main should be at the farthest possible point from the furnace to intercept the blast from the nearest stove, in order that the cold and hot blast may have as great as possible time to thoroughly mix, as otherwise there is danger of the cold and hot blast entering the bustle pipe, or circular main, from which the tuyere connections are fed, not thoroughly mixed, when some of the tuyeres will receive blast of higher temperature than others with consequent uneven working of the furnace.

3. *The Raw Material Supply Plant.*—While unquestionably economy in the cost of handling the raw mate-

Generated on 2024-09-08 15:46 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

rials for supplying the furnace has grown to be a first consideration in the design of the plant under this heading, particularly in recent years of high labor costs, the original incentive to the adoption of mechanical handling was rather one of necessity. The rapid increase in blast furnace outputs necessitated such large quantities of materials that they could not be efficiently handled, if at all, by the older methods of manual labor. It was therefore necessary to install mechanical charging devices. Labor displacement rather than necessary labor saving was the primary incentive, though the latter was undoubtedly recognized as an important consideration.

A very important labor saving feature is that the raw materials shall be delivered to the works, when by rail, in self discharging hopper wagons of as large capacity as possible, with "one man" opening and shutting doors; when by sea direct from ship, by means of large capacity grabs to a transfer traveling bridge, which delivers the material so received direct to the furnace bins, to the stockyard situated adjacent to the bins, and directly under the transfer bridge, or into railway cars. The bins usually consist of a double row of slanting bottomed enclosures, constructed of steel or concrete, varying in number according to varieties of ores used, and running usually in a direction perpendicular to the length of the transfer bridge, the inclination of the bottom being towards the center line between the two rows of bins and at an angle somewhat greater than the angle of repose of the materials. The bins are each of moderate capacity, but in total capacity usually sufficient to supply the furnace for from 48 to 72 hours only, as by means of the transfer bridge ample facilities are at hand to keep them filled from the stock piles if necessary. Each row of bins forms the support for a standard gauge railway track for conveying to and discharging into the various bins such materials as are received in railway wagons. A transfer car also runs on this track, or on a separate track supported by the bins, for distributing the materials delivered by the transfer bridge from the stock piles or direct from the ships. The railway cars are elevated to the roads over the bins, either by an electric lift, or over an incline where there is sufficient room, the wagons descending to the ground level either over the same incline or a similar one at the other end or by means of a wagon drop.

Below and on the center line between the double row of bins there runs an electric transfer car for conveying the materials from the bins to the hoist skip or bucket. The materials are discharged from the bins by gravity into a receptacle on the transfer car, through suitably controlled openings situated at the lower limit of the inclined bottoms of the bins. The transfer car also carries as an integral part of it a weighing machine, upon the beams of which rests the receptacle for receiving the materials from the bins, so that any predetermined weight of material may be discharged into the transfer car receptacle from any particular bin. The whole of the operations in connection with the transfer car are carried out by the driver of the car, whose position is such that he has under his control and observation the discharge of the materials from the bins, the weighing of the materials, and the driving of the car. The capacity of the transfer car is such that it can deliver in each trip a quantity equal to the maximum load of the hoisting skip or bucket.

Various means are in use for assuring that the materials are well distributed as they discharge into the transfer car receptacle. From this receptacle the materials are discharged through a suitably controlled door in the bottom into the hoist receptacle, or, as in some arrangements, the transfer car receptacle is hoisted direct from its seat on the car to the top of the furnace.

Several methods of hoisting the materials to the top of the furnaces are in use in modern blast furnace equipment, which may be divided into two classes—the skip inclined hoist and the tub or bucket hoist, the latter consisting of either an inclined bucket hoist, or a vertical bucket hoist with a horizontal transfer bridge at the top. As usual where several methods are in use for doing the same thing, engineers and operators differ as to which provides the greatest number of desirable features for its purpose. As far as this paper is concerned, however, the purpose is the same in each method, and the author does not, therefore, propose to enter into a discussion of their relative merits.

That purpose is obviously to deliver the solid raw materials required in the production of pig iron to the top of the furnace, and to distribute them as uniformly as possible on and around the furnace charging bell. This is a feature of the greatest importance, as has been shown in the discussion of the question of distribution under the section on Preparation of Materials.

4. *The Output Disposal Plant.*—The principal output from a blast-furnace is, of course, pig or molten iron, the others being slag and gas.

With modern blast-furnace equipment the pig, or casting, bed has ceased to exist as an essential part of the furnace equipment, the whole of the output being run into ladle cars of varying capacity, from the simple open top type of 30 or more tons to the large enclosed type of 100 or more tons capacity, though in some cases even the use of hot metal ladle cars is eliminated, as will be described later in connection with the casting machine. When the molten metal is taken to the steelworks receiver or mixer there is an end of it as far as the blast-furnace is concerned, excepting when the quality is not satisfactory to the steelworks manager. When all or any portion of the output is required in the form of pigs, the molten metal is run into ladle cars for conveyance to a casting machine, which is usually located at some point away from the furnace, convenient to railway connections, or as in some more recent arrangements, the casting machine is located adjacent to the furnace, the molten metal being run direct into a receiver from which it is teemed into the casting machine feeding troughs, thus eliminating the necessity for hot metal ladle cars, except for such molten metal as is required for steel-making.

Though several types of pig-casting machines have been designed, the original or Uhling design, with various modifications and improvements for handling the molten and cold metal, is the type most usually installed at present. This machine consists of an endless chain of cast-iron moulds of about 100 lbs. capacity each, and of a shape to allow a free discharge of the cold metal. The moulds are key bolted to a flexible frame carried on small flanged wheels which run on an inclined way rising from the pouring end. The molten metal is poured from the ladles, which are tilted by a power device, into a shallow basin from which it runs through feeding troughs into the moulds as they rise slowly from their return journey and pass under the discharge end of the troughs. To prevent the molten metal burning or sticking to the moulds, they are coated with a solution of limewater, which is sprayed upon them as they return to the pouring end upside down, under the machine, the limewater being blown upward

Generated on 2024-09-08 15:51 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

by air jets in the lime tank. Owing to the heat of the moulds they quickly dry in readiness for the molten metal before they reach the feeding troughs. At the upper end of the train of moulds as they turn over to begin their return journey, the metal, which by this time has solidified (the incline is designed of sufficient length for this purpose), freely falls from the moulds on to a shute from which it discharges either direct into steel-bodied cars where it is water-sprayed for cooling, or on to an inclined travelling endless plate conveyor which passes with its burden of hot pigs through a water-filled tank of a length sufficient to cool the pigs below the ignition point of wood. At the upper end of the conveyor as it turns for the return journey the cold pigs slide off into a shute and are discharged into railway wagons.

Machines are built single strand or multiple strand according to the capacity required, each strand consisting of a single chain of moulds having a capacity of roughly 500 tons per 24 hours.

While the structural parts of these machines were formerly built entirely of steel they are now construced of ferro-concrete, owing to its more lasting qualities and lower cost. In addition to the necessary facilities which it provides for casting the large outputs of the modern blast-furnace, the pig-casting machine, the successful and satisfactory operation of which has been thoroughly demonstrated through many years of use, has very much simplified the handling of molten pig iron by eliminating the many objectionable features of the older method of casting in sand beds, and breaking by hand or by hydraulic or electrical pig-breaking machines, besides effecting considerable economy of labor and saving in waste.

The disadvantages of sand-bed casting and the advantages of the machine method of handling molten pig iron may be enumerated as follows:

Disadvantages of the sand-casting method:

(1) Difficult and high-priced labor required.

(2) Large quantities of clean sand required.

(3) Imperfect results, core jumps, plated beds, irregular breaking, and irregularity in sizes of pigs and sows.

(4) Heavy waste in runner scrap.

(5) Slower melting of sand-covered pigs, and cost of melting the sand on the pigs, in the steel furnace.

(6) Deleterious effects of sand-covered iron in basic steel furnaces.

Advantages of the pig-casting machine method:

(1) Immediate removal of molten metal from the immediate vicinity of the blast-furnace. (This, of course, does not apply where the metal is run direct into a receiver adjacent to the furnace, as above described; but the author believes this arrangement has not yet been widely adopted, and is of opinion that, notwithstanding the slightly extra cost of ladle cars, it is better to remove the molten metal to a safer distance, in view of the disturbances which sometimes occur in the immediate vicinity of blast-furnaces through breakouts, explosions, etc.)

(2) Practically no manual labor required.

(3) Sand-free iron.

(4) Uniform size of pigs of iron, and no heavy sow pieces.

(5) Facilities for disposal of the output always in readiness.

(6) Great reduction in runner scrap produced when casting.

(7) Saving labor charges.

(8) No core-jumps or plated beds (unsaleable iron requiring extra labor for breaking and handling).

(9) A difficult and very trying class of labor is dispensed with.

(10) Where week-end iron only is cast, the difficulty of finding special labor for these days only is eliminated.

A discussion of this heading would not be complete without reference to the slag and gas, both of which form part of the furnace output.

While there are no special methods of slag disposal which may properly be said to apply particularly to modern blast-furnace practice, it may not be amiss to refer to some of the methods in use at modern plants.

The most usual method is, of course, that which is now generally used at all, except the oldest, layouts (where the slag is still run into beds, allowed to cool, then broken by hand or drop ball, and shovelled into wagons), that is, by means of large capacity, self-discharging, mechanically operated slag ladle cars, in which the slag is conveyed to some point more or less distant to get it out of the way.

Where, however, recovery of the slag is desired for special commercial purposes, special methods are used, such as blowing steam through the molten slag for the production of slag wool; running the molten slag into tanks of water for granulating for cement making or other uses; running into special receptacles and cooled in layers for producing a solid product for concrete making, etc. As stated, these processes are for special purposes, and do not apply generally.

With regard to the gas there are a few points also which may be mentioned.

In view of the large volumes of gas produced in modern furnaces with large outputs, it is of great importance that ample areas shall be provided in the gas out-takes at the furnace top, not only to provide for the large volume of gas to be discharged through them, but also to reduce its velocity to a minimum, in order to lessen as much as possible the tendency for the smaller particles of solid materials to be mechanically carried out with the gas. For this purpose it is usual to provide four equally distant outlets of the largest size consistent with structural safety. These outlet connections are inclined as steeply as possible upward, and are carried well above the furnace top before the gas is admitted to the downward connections, in order that any larger materials, which may at times be projected from the furnace, may fall back into it and not enter the downtakes.

In some designs baffles are placed in the elbow of the uptakes in such a position that they will intercept these heavier pieces, thus avoiding the necessity for carrying the uptakes so high. A further reason for the multiple equidistant outlets is to prevent any tendency of the gases in the upper portion of the furnace to channel towards one side, as they tend to do in older furnaces with one outlet, thus reducing the active area in the upper reducing zone of the furnace.

Method of Operation.

In the foregoing pages the author has endeavored to define in some detail those factors which enter into,

Generated on 2024-09-08 15:46 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

and make possible, modern blast-furnace practice. They are the elements out of the adoption of which that practice has developed. He has therefore designated them "The Bases of Modern Blast-Furnace Practice."

Certain operative features have necessarily been referred to in connection with the discussion of these factors; but so many of the details of operation, or management of a blast-furnace, are based on practical knowledge, acquired only by years of experience and common sense, that any detailed discussion of them is not possible in a paper of this nature.

It would not, however, be complete without some reference to an essential difference in the method of operation by which the improvements in results, made possible by the adoption of these factors, are obtained, and the method of operation still prevalent in many localities where modern practice has not been adopted. In modern practice the nearest possible approach to uniformity in all controllable factors is a first principle in order to obtain the nearest possible approach to uniformity of action within the furnace. Reference has already been made to the importance of this question of uniformity in various connections, **including uniformity or regularity of blast volume, irrespective of furnace pressure or resistance.** In the older practice just referred to as still prevalent in many localities, the volume of blast is varied with the furnace resistance, that is, the varying conditions within the furnace are permitted to cause lack of uniformity or irregularity in the volume of blast delivered to the furnace. This method being contrary to the principle of uniformity of all controllable factors is totally inapplicable to modern practice.

As the principle involved in the comparison of these two methods of operation were outlined in some detail in the author's evidence before the Iron and Steel Industries Committee, he will not state them here. Suffice it to say that blowing by constant volume irrespective of furnace resistance is the method of operation essentially employed in modern blast-furnace practice.

The actual volume of blast per minute, the number, size, and length of projection of the tuyeres inside the crucible walls, the weight of coke per round of charge, the rotation of coke, ore, and flux in the charge, the degree of bosh wall cooling, etc., are all operating conditions determinable, for any particular furnace and set of materials, within certain limits by experience only.

BOOK REVIEW

Methods of the Chemists of the United States Steel Corporation for the Sampling and Analysis of Pig Iron.

Ed. 2, 40 pages, 1922. Carnegie Steel Company, Bureau of Instruction, Pittsburgh.

In 1896 a committee of the Engineers' Society of Western Pennsylvania edited and published "Methods for the Analysis of Ores, Pig Iron and Steel in Use at the Laboratories of Iron and Steel Works in the Region about Pittsburgh, Pa." The chairman of the editorial committee was the late Dr. Francis C. Phillips, and the methods contributed bear the names of some of Pittsburgh's most eminent metallurgists; the first two contributions, for example, are by John S. Unger and Frederick Crabtree who 25 years ago were in charge of local steel-works laboratories. Some 20 pages are contributed by J. M. Camp, but these contributions do not adequately indicate Mr. Camp's connection with the enterprise. He was in a large measure responsible for the project of compiling and publishing the collected methods; he arranged for the editorial services of Dr. Phillips; and the influence of his own practice during a long experience in local laboratories is reflected in certain contributions from other sources.

The above publication was a praiseworthy attempt to record the general practice in laboratories in the greatest steel-making center of America. In many laboratories it has been superseded by the "Methods" of the chemists' committee of the United States Steel Corporation. This committee was formed in 1907 to standardize practice in the laboratories of the corporation, and J. M. Camp, formerly chief chemist of the Duquesne Works of the Carnegie Steel Company, was appointed chairman.

The "Methods" of the Chemists' Committee have appeared in eight pamphlets each dealing with one definite problem in steel-works analysis. One of the earlier of these, concerned with the sampling and analysis of pig iron, was published in 1912 as a pamphlet of 34 pages. Its value was immediately recognized and approximately 1,500 copies were distributed. But during the past decade numerous shortcuts and refinements have been made in steel-works analysis, and many of the methods set forth in the original pamphlet no longer represent the best modern practice. The new edition, just published, has been largely rewritten. In its preparation the Chemists' Committee canvassed the various laboratories of the corporation and gave due consideration to all improvements in methods appearing in the original edition. One noteworthy advance featured in the new edition is the distinct improvement in carbon combustion apparatus.

Directions are clear and concise, and accompanied by drawings where necessary, as in the case of the test-piece and mold for sampling molten pig iron. Though intended for trained chemists, there is a brief statement regarding the character and use of reagents.

The chairman of the Chemists' Committee, J. M. Camp, is in charge of the Bureau of Instruction of the Carnegie Steel Company, and his experience in the instruction of employees of this company, coupled with his lengthy technical experience is doubtless largely responsible for the value of the methods and the excellence of their presentation. It is interesting to note the personnel of the sub-committee with whose co-operation the present pamphlet is produced. The original sub-committee in 1912 consisted of W. B. N. Hawk, William Brady, and C. H. Rich. The first two of these men are retained on the present sub-committee. C. H. Rich (deceased) was in 1912 chief chemist of the Clairton works of the Carnegie Steel Company. He was succeeded in that position by I. A. Nicholas who was later succeeded by H. E. Cambell who constitutes the third member of the present sub-committee.

The pamphlet is obtainable from the Bureau of Instruction, Carnegie Steel Company, Carnegie Building, Pittsburgh.

E. H. McClelland,
Technology Librarian.

Carnegie Library,
Pittsburgh, Pa.

Generated on 2024-09-08 15:47 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

By-Product Coking with Particular Reference to New Combination Oven

Fig. 1—Coke produced from 100 per cent Yorkshire coal coked at Seaboard By-Product Coke Company.

Comparison of American and European Methods of Coking, Giving Reasons for Superiority of Our Practice. Description of the New Koppers Oven.

By JOSEPH BECKER

Fig. 2—Coke produced at Seaboard By-Product Coke Company from 100 per cent Durham coal.

BEFORE entering into the subject of this paper, perhaps it would be well to mention briefly the remarkable development which has taken place in the by-product coke industry in the United States in the past decade, particularly in its relation to the iron and steel industry with which it is so closely identified.

Not quite 15 years have elapsed since the United States Steel Corporation installed its first by-product coke plant of Koppers design, at Joliet, Ill., and since blast furnace operators were looking with doubt and suspicion on the by-product coke oven as a source of blast furnace fuel; but in this comparatively short time, the by-product coke oven has come to be an essential part of an economically operated iron and steel plant. It is not necessary for us to go into the causes leading up to this development—they are too well known to require even mentioning—but it is only fair to say that this result was only possible through the close co-operation which blast furnace operators have extended to those of us who had to do with the operation, construction and design of by-product coke ovens.

American By-Product Coke Oven Practice Superior.

It is no idle boast to say that America By-Product Coke Oven practice leads the world today—this despite the fact that the by-product coke oven originated and was in general use on the continent before it was even thought of in the United States. The writer had an opportunity last year to visit Europe and to study European by-product coke oven operation very carefully and what he saw convinced him that from the standpoints of quantity production per oven per day and quality of product, European practice is many years behind us. That very little, if any, progress has been made there in the past 10 or 15 years is brought out very clearly in an article in the September 2nd issue of "The Gas World" of London, describing an installation of 100 ovens for the purpose of carbonizing 540 tons of coal per day. This article goes on to say that the plant previously consisted of 100 horizontal flued waste heat ovens which have been in operation for 15 years. These ovens have a capacity of 7 tons and the 100 ovens carbonizing 500 tons of dry slack coal per 24 hours. This would be equivalent to 31 hours coking time. The additional 100 ovens recently completed are of the vertical flued type, and have a capacity of 7½ tons each with a carbonizing capacity of 540 tons of dry slack per day. This would be equivalent to a coking time of about 33 hours. This very strikingly shows that at least on this plant no progress has been made with respect to increasing the coking capacity per oven. It is remarkable that after 15 years a new plant is built which has even less carbonizing capacity per oven per day than the old plant, in spite of the enormous progress that has been made in the United States during the same period in the way of increasing oven capacity. This is merely citing one instance of English coking practice and the majority of English coke plants operate under very similar conditions. One wonders why conditions are not changed in England, in view of the large number of visitors who come to the United States every year to investigate our by-product coke plants.

The writer has observed similar things during his last year's visit in Germany. There have been recently put into operation ovens of the Koppers type, which are heated with blast furnace gas and which are supposed to operate on 18 hours coking time. These have an average width of about 16 inches and a length of about 32 feet between doors, making a carbonizing capacity of about 14½ tons per oven per day. This is very likely the largest capacity of any type oven of similar dimensions in Europe. However, even this capacity is low when compared with American coke oven capacities. Modern American ovens carbonize more than double the quantity of coal per day that can be coked in ovens as built in Germany and England. The Koppers Company has recently contracted to build a plant to carbonize 1,000 tons of coal per 24 hours in 37 ovens. The ovens are designed to carbonize

*From a paper presented before the Eastern States Blast Furnace and Coke Oven Association at Buffalo, N. Y., October 5, entitled, "Modern By-Products Coking with Particular Reference to the Koppers Company New Combination Oven A." The author is Consulting Engineer, The Koppers Company, Pittsburgh, Pa.

Generated on 2024-09-08 15:46 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

30 net tons of coal per oven per day, and are of a type to be described later in this paper.

The question now arises—what is the reason for this great difference in coking speeds? Many have been advanced by our European contemporaries, the most prevalent of which is that they have to carbonize

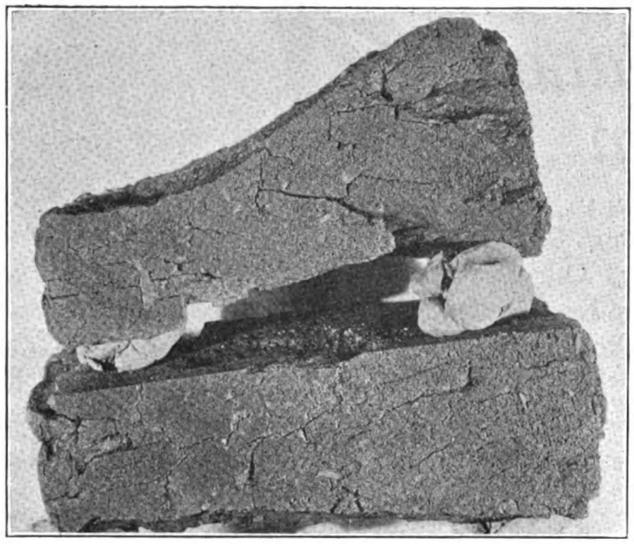


FIG. 3.
Coke section 100 per cent Durham coal coked at Seaboard By-Product Coke Company.

wet washed coals and that this makes it impossible for them to attain the same coking speeds possible here. This does not sound quite reasonable, and furthermore it is a fact that several plants in this country are using washed coals averaging 12 per cent moisture and more, and carbonizing them in from 15 to 17 hours in Koppers ovens averaging 17 inches in width.

Another reason given is that the character of their coals is quite different from those found here. The writer has made an examination of the analysis and

FIG. 4.
Coke from Yorkshire, England, coal coked in five-oven battery at Chicago in 11 hours.

coking qualities of the various coals found there, and in general they correspond very closely to the coals found in this country—so this argument does not seem to hold.

Most striking proof of the fallacy of both these arguments was given during our recent coal strike, where several companies operating by-product coke plants imported large quantities of English coals to avoid curtailing operations. The Seaboard By-Product Coke Company at Jersey City, N. J., received over 100,000 tons of English coals such as Yorkshire and Durham coals, and coked them in 16 hours continuously with the same ease as American coals of different varieties used there, producing coke of very good quality for metallurgical purposes (see Figs. 1, 2 and 3). About 100 tons of Yorkshire and Durham coals were sent to the Chicago By-Product Coke Company's Coke Plant and separate coking tests were made in the new five-oven battery. These coals were perfectly coked at a coking time of 11 hours, without the slightest difficulty, and the coke produced was just as good for blast furnace use as any coke made in the Pittsburgh District from Pittsburgh coals (see Figs. 4 and 5). The capacity of this oven on these coals is, therefore, 25 net tons per oven per day.

Unquestionably one reason for their not being able to attain our coking speed is the fact that they do not generally use silica construction. On the other hand there are ovens of this material over there; but these have not attained anything approaching American practice.

FIG. 5.
Coke from Durham coal coked in five-oven battery in 11 hours at Chicago.

Reasons for Superiority of American Practice Over Foreign.

In the writer's judgment, the difference in capacity of the American ovens as compared with those in Europe is due entirely to the proper use of properly manufactured silica material **throughout,** combined with better design, and last but not least, better operating organizations and more systematic operation.

The organizations operating the coke ovens in America consist generally of technically trained men with good practical experience, the latter not being generally the case in Europe. American operators have more tenacity in solving problems and difficulties in organization and operation in order to attain greater capacities from their plants and do not offer excuses for inability to maintain a high output as is done abroad. One of the most important features of organization to be found in American coke plants is the strikingly systematic operation of the ovens. Ovens are heated by intelligent heaters and most of the assistants and superintendents of American plants have passed through the entire school of by-product coke oven operation, beginning as heaters. Even in cases where this is not so, the assistants and superin-

Generated on 2024-09-08 15:48 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

tendents fully realize the importance of oven heating and consider the oven operation the "heart" of the entire by-product coke plant. In European operation, on the other hand, insufficient talent and talent of a lower quality are employed to take care of the ovens. The result is that coke oven batteries need frequent repairs and relining, often after only three to five years of operation. In making this statement, I do not refer to plants using highly expanding coals or coals containing excessive amounts of sodium chloride which are coked in clay ovens instead of in silica ovens. The usual class of heaters employed in Europe are men who are not acquainted with combustion problems and who operate the ovens by rule of thumb methods. In most plants, it will be found that there is no pushing schedule at all. Ovens are picked out and pushed as they become ready so that it can be stated as a general rule, the ovens on the Continent operate the heaters, while in America the heaters operate the ovens. Taking all these things together, the result is that America can make the same quantity of coke from the same coals in less than one-half the number of ovens.

Another excuse usually offered is that with our fast operation we destroy by-products. The writer had

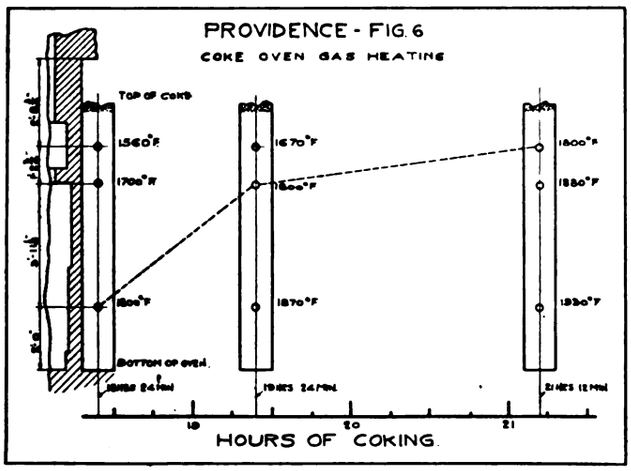


FIG. 6.
A heat progression chart for the old type Koppers oven.

an opportunity to investigate this and finds that the by-product yields here are fully equal to those obtained in Europe.

The same inefficient operation described above can be found in European blast furnace practice and the poor operation of their by-product coke plants is a great contributing factor thereto. In America there is the closest co-operation between blast furnace and coke oven operators.

As is usual in American industrial practices the natural tendency in the building of coke ovens has been to attain a maximum capacity per unit oven while simultaneously producing a good quality of coke. Therefore the development in America has been a gradual increase in the size of the ovens. The use of high grade silica throughout the structure has reduced the time required for coking very considerably as compared with the use of clay bricks. But beyond the increase of capacity an improvement of the design of the ovens proper was necessary that long and high ovens could be built with proper heat distribution over the considerably increased coking areas.

The problem of designing ovens which would assure a perfect distribution of heat over such large areas was a difficult one. A great number of coke plants were desirous of coking 100 per cent high volatile coals. The blast furnace practice showed that coke made from such coals should be pushed at relatively lower temperatures. When pushing coke made at low temperatures, any uneven heating conditions in the ovens becomes much more pronounced and visible than when pushing hot coke. Furthermore, it is a matter of course that the heating system of ovens of large capacities has to allow passage of larger volumes of gas such as waste products of combustion through their flues. This calls for proportionately larger areas to convey such gases, in order to prevent great pressure drops throughout the heating system, which would seriously interfere with the proper operation of the ovens.

The Koppers ovens with individual regeneration and flame heating in the flues produce very good coke in ovens of the capacity commonly in use today. The heating from the bottom up to the horizontal flue is practically uniform, however, the region of the horizontal flue lags behind in coking. Fig. 6 shows a typi-

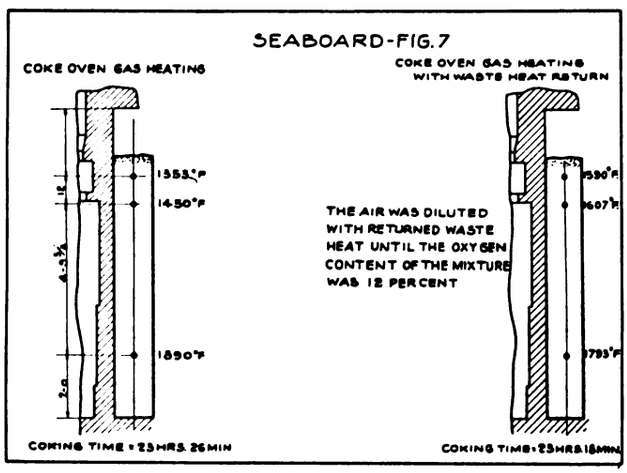


FIG. 7.
Heat progression chart for coke oven with waste heat return.

cal progression of temperature into the coal charge at various places in such an oven. These readings were taken by inserting thermo-couples through the Pusher side door four feet into the coal charge; one was located two feet above the oven floor, one just below the horizontal flue and another one at about the center line of the horizontal flue. The figures given herein are an average of a great number of readings and exhibit in general the conditions as they exist in practically all the Koppers coke ovens which are heated reasonably well and operated to capacity. This indicates that the space occupied by the horizontal flue is quite appreciable and the amount of coke in the upper region of the ovens being affected by the location of the horizontal flue is an appreciable percentage of the total coke made. This condition is tolerable, particularly when the ovens are pushed without waiting until the upper part is thoroughly coked, and such coking operations with these ovens have given very good blast furnace results. These ovens have an average capacity of about 18 to 19 net tons of coal per 24 hours.

It will be interesting to know the results of an investigation of the heat progression in the coking charge

Generated on 2024-09-08 15:47 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

in an oven that was designed for 17 hours' operation but operated between 23 and 24 hours. Such tests were made at the Seaboard By-Product Coke Company's plant by inserting thermo-couples in the coal charge in the same way as in the tests described before. The test disclosed that on that coking time the lower part of the oven coked decidedly faster than the part below the horizontal flue. When the lower part of the coke reached the temperature of 1,890 deg. F., the part below the horizontal flue only had a temperature of 1,450 deg. F. These temperature differences could, of course, be expected, because when operating on a longer coking time the quantity of gas per flue becomes correspondingly less and combustion is relatively quicker, thus causing a quicker progression of the coking in the lower part as compared with the upper part of the oven.

Uniform Heat Distribution Important.

As far back as 1914, Dr. Koppers proposed as a means of evening out temperatures within the heating system of coke ovens, the addition of waste gases to the air required in order to retard the combustion of gases in the heating flues because of the reduced content of oxygen in the waste gases and air mixture and thus lengthening the flame, resulting in an improved heat distribution and temperature progression within the coal charge. This process was tried out at Seaboard and Fig. 7 shows the result of the addition of waste gas till the mixture of waste gas and air contained 12 per cent oxygen. The waste gas was taken from the stack by means of a fan and blown into the air boxes on the regenerators, while the air was drawn in according to the regular practice. The temperature mentioned before when operating on between 23 and 24 hours were decidedly changed and shows that the bottom temperature was reduced to 1,793 deg. F. while the temperature below the horizontal flue was increased to 1,607 deg. F., simultaneously increasing the temperature in the coke near the region of the horizontal flue to 1,590 deg. F. This test was carried on for several weeks and it was shown that when the fan was taken off the temperature went back to the original ones as mentioned before. This test proves that the return of waste gases in ovens which have unequal heating conditions from bottom to top will greatly help the distribution of heat progression in the coking charge. It is a good cure for ovens which suffer from hot bottoms as it causes a condition in the heating flues which is similar to that existing when using blast furnace or producer gas. Blast furnace and producer gas are most excellent fuels for heating the ovens because such gases have a slower combustion speed and distribute the heats very uniformly.

Principles of Design.

It is the belief of the majority of coke oven and blast furnace operators that, especially from high volatile coals, better coke can be made in narrower ovens. In making the oven narrower, the coking capacity per 24 hrs. would necessarily be reduced unless a considerable multiplication of the operations would be resorted to. The first thought would naturally be to compensate for this by building higher and longer ovens and thus increasing the tonnage per oven per 24 hours. This would mean that the horizontal flue, with the type of oven as mentioned before, would have to be enlarged and thus occupy a larger space in the coking region, thereby retarding the coking of a proportionately larger amount of coal in that region. Furthermore, when

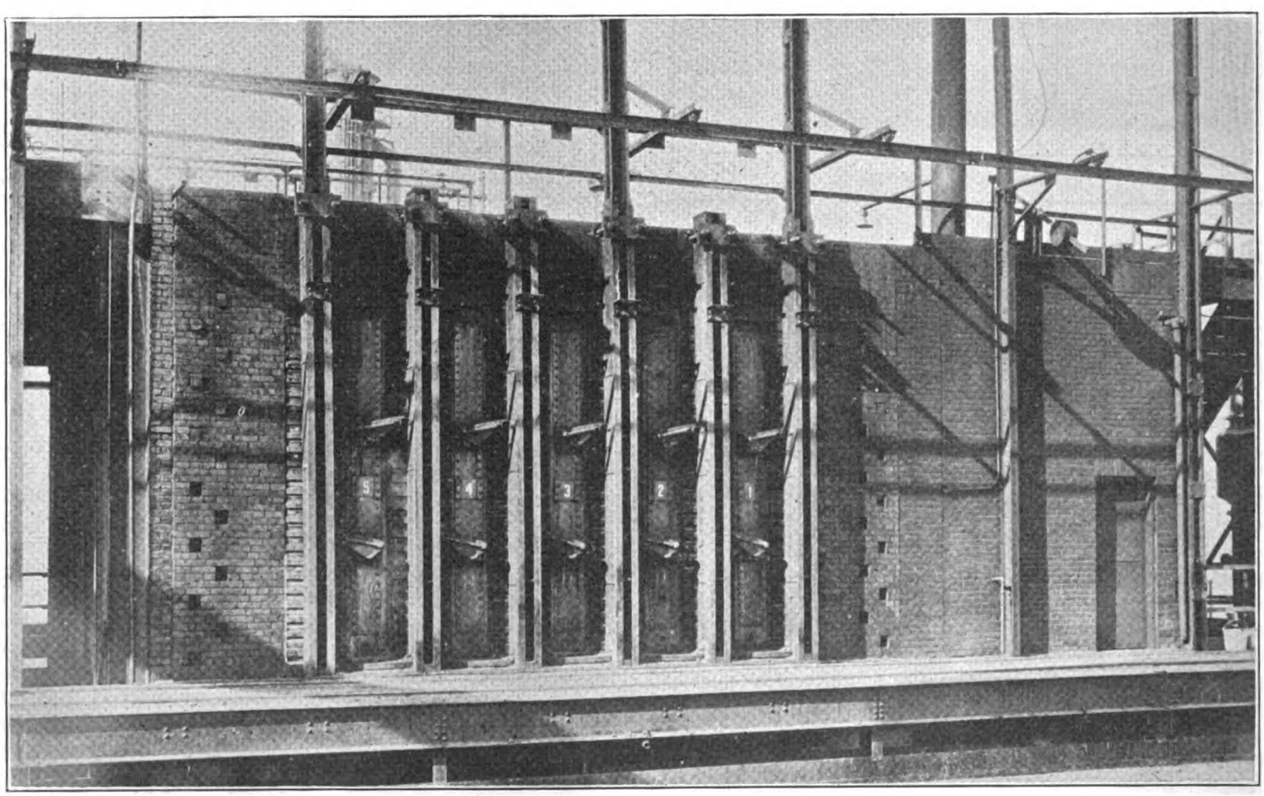


FIG. 8.
Coke side of new combination type Koppers ovens at the plant of the Chicago By-Product Coke Company, Chicago.

Generated on 2024-09-08 15:50 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

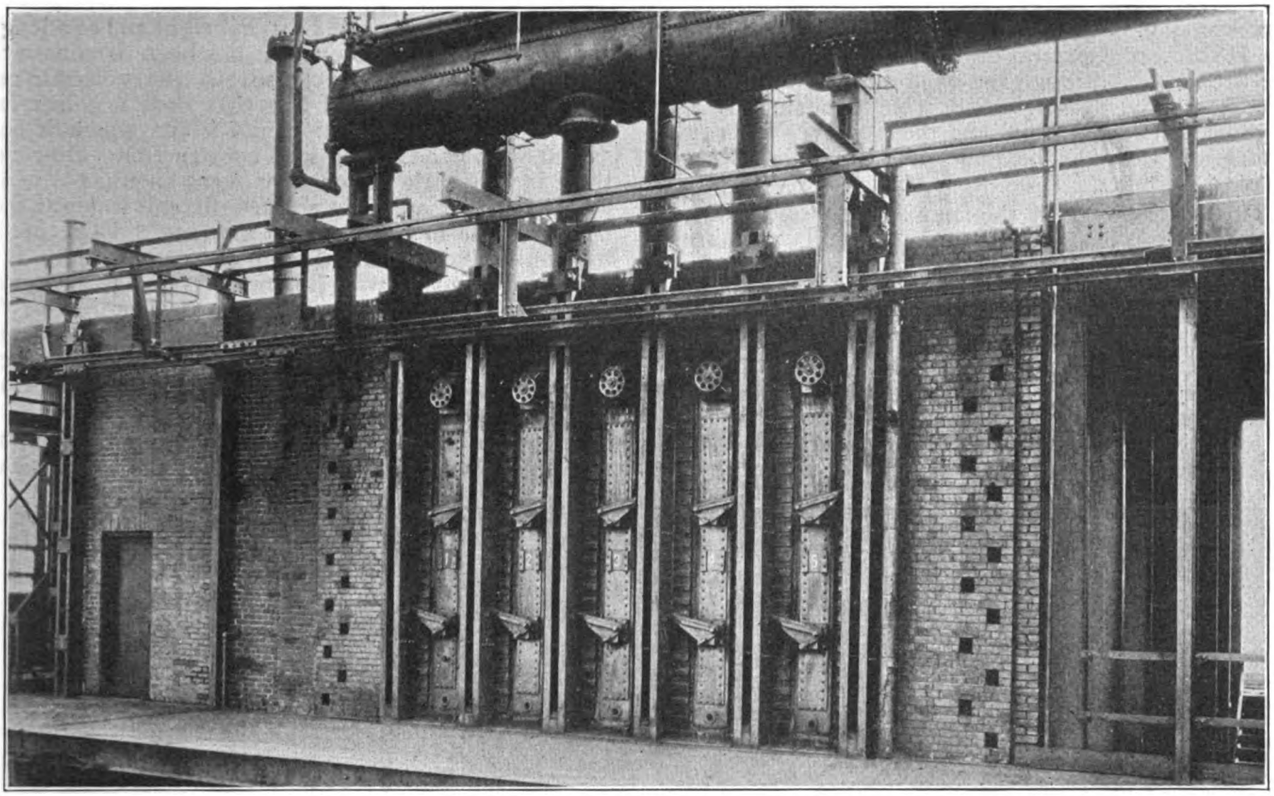


FIG. 9.
Pusher side of new Koppers oven at the Chicago By-Products Coke Company, Chicago.

equipping ovens so that they can be heated in the future with producer or blast furnace gas which is unquestionably the proper construction, this flue must be enlarged again in order to make it carry the additional amount of inerts present in such low Btu. gases. It, therefore, was apparent that the oven as it stood should not be increased in capacity without making changes in the design eliminating the effect of the horizontal flue on the heating conditions and thus eliminating its effect on the quality of coke produced. Also with increased capacities a relatively smaller horizontal flue would require an exaggerated closing of the discharge openings of the vertical flues to such an extent that the drop of pressure through the reduced openings would become too high for the best draft conditions throughout the oven structure. It is, of course, fully recognized that an oven can only be successful in operation, production and length of life provided the draft in the heating flue system be kept at the very minimum.

It might be thought best by some to design ovens without any horizontal flues. Such ovens without horizontal flues usually operate in such a manner that adjacent vertical flues serve alternately as up-burning flame flues and down-going waste gas flues and vice versa. It is evident, however, that an oven in which all adjacent heating flues or at least a large group of them serve at the same time in their entirety as up-burning flame flues or in their entirety as down-going waste heat flues, is not subject to the danger of different draft conditions between adjoining flues. In this case, the up-burning flame flues can under no condition be affected by adjoining down-flow flues in case there should be any leakage in the brickwork separating such flues, a condition which can easily occur especially as the ovens become older. Furthermore, the arrangement of the gas supply flues in an oven in which the gas is burned up in one flue and down the next adjoining one is usually such that this gas supply flue is paralleled by an up-going regenerator on the one side and a down-going regenerator on the other side. This arrangement greatly increases the difficulty of keeping the gas supply flues tight. Also all ovens should be built so that producer gas or blast furnace gas could be used advantageously in the future, and in up and down-flow flued ovens, there will always be a counter current between waste gas and gas in regenerators, as well as between adjacent flues. All these dangers of leakage between adjoining flues are non-existing in ovens with paralleled flow and it is, therefore, clear that it is best to retain a horizontal flue because it insures simplicity in design and the greatest safety in operation of the ovens. Furthermore, it makes the system readily adaptable for the use of blast furnace and producer gas, without the objectionable counter currents.

Experimental Ovens Tested In Chicago.

These leading principles in oven construction have been tried out by the Koppers Company in a battery of 5 ovens at the plant of the Chicago By-Product Coke Company at Chicago. The five ovens were put into operation on February 1, 1922, and have since that time operated continuously on a great variety of coals at coking times between 10 and 12 hours. Fig. 8 shows the coke side of this battery; Fig. 9 shows the pusher side, and Fig. 10 shows the location of this battery in connection with the rest of the ovens. The new oven has a length of 37 feet between doors, a height of chamber of 11 ft. 8 in. and an average width of 14 ins., the taper between coke side and pusher side being 1½ ins.

Generated on 2024-09-08 16:12 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

Cast iron jambs are used at the ends of the ovens. Fig. 11 shows the general design of the new type oven. The vertical cut through the oven lengthwise the battery shows the heating walls, coking chambers, arrangement of regenerators and the crossover flue communicating with the heating walls on both sides of the oven chamber.

This shows that in this new design one side of the coke oven is heated in its entirety, that is, gas burns simultaneously on the coke side and on the pusher side, the products of combustion then join in the respective horizontal flues, pass through the crossover flues, one of which is located on the coke side and the other on the pusher side. Thence the products of combustion enter the respective horizontal flues of the adjacent heating wall and pass downwards throughout the entire wall into the respective regenerators. It is evident that the cross sectional area of a horizontal flue when operating in such a way can be considerably reduced as compared with the horizontal flue in ovens of the former design. This allows us to locate the horizontal flue higher than was previously possible and it furthermore allows the use of heavy walls between the horizontal flue and the coal chamber. This gives sufficient space to use insulating material if necessary in order to prevent any overheating of the gas space in the oven chamber. The insulation of the crossover flues at Chicago has been found to be entirely satisfactory and effective.

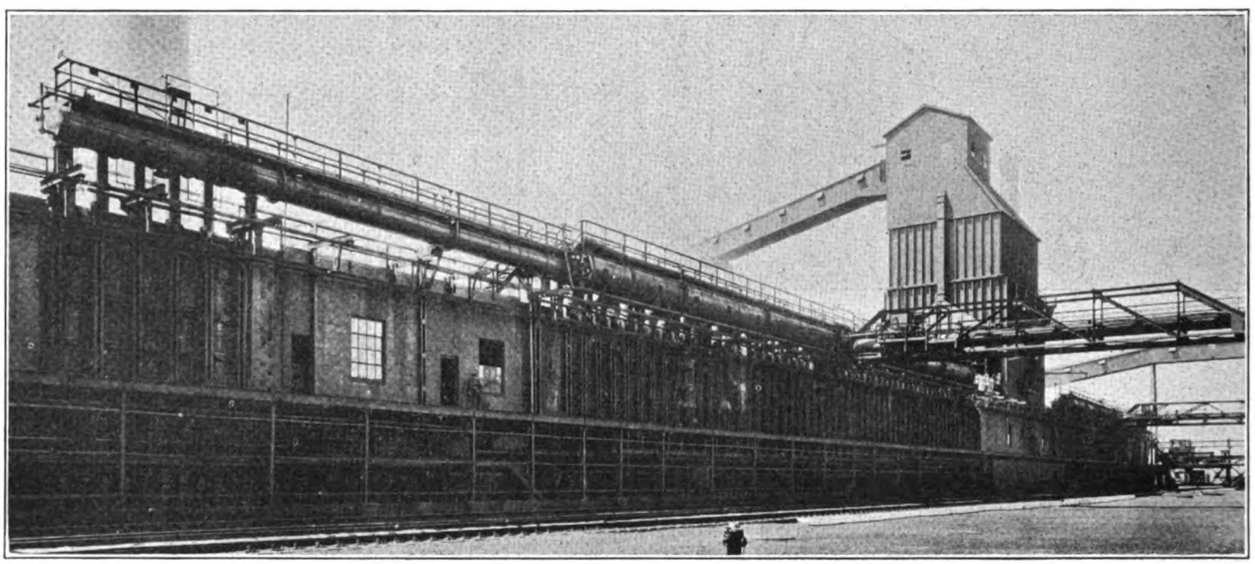


FIG. 10.
Pusher side of ovens at Chicago By-Product Coke Company with new type combination oven in the foreground.

Increased Height of Flame Flue Heating.

One of the most important achievements claimed for this new design is the fact that the height of the flame flues has been considerably increased and these now extend as far up towards the top of the coal charge as is necessary for uniform heating of the entire charge. Thus the interference of the horizontal flue with the flame flue heating has been entirely eliminated. Of course the number of crossover flues could be increased beyond two perferably to five, the crossovers passing through the available spaces between charging holes. The size of the horizontal flue would thus of course be still more reduced, without causing an additional pressure drop. For ovens of 12 ft. in height and of a length similar to the Chicago oven, it has been demonstrated at Chicago that only two crossovers are required to permit a size of horizontal flue that does not interfere with flame flue combustion and a flue which is consistent with good strong wall construction. However, there is very little reason why ovens should not be increased further in height and length, and it might then be preferable in order not to increase the size of the horizontal flue to build three or five crossovers. It is clearly shown that with this new design the size of an oven has become independent of areas required for the former horizontal flue which interfered with the perfect operation of the ovens, especially when they were of great capacity, since it is important to retain the advantageous functions of horizontal flues.

It should be emphasized that on account of the fact that an entire side of a coke oven chamber serves either for up-flow combustion or down-flow products of combustion, any leakage between individual flues become of little consequence because all the gases flow either up or down and each flue is operating under the same pressure conditions. Since there is absolutely no counter flow in any of the heating flues, it undoubtedly constitutes the safest construction for flame heated coke ovens. It will also be noticed that the regenerators reverse longitudinally with the battery instead of crosswise as in the former design. The usual longitudinal taper of a coke oven requires that larger amounts of fuel gas are used on the coke side as compared with the pusher side. In the type of oven formerly built, products of combustion from the coke side of the oven chamber exchange their heat with the air or air and gas going up to the narrow pusher side. Since for the latter side gases are required in smaller volume, the efficiency of the heat exchange varies with reversals as is shown by fluctuations in the stack flue temperature. In this new construction the in-going gases for each half of the oven are regenerated with the products of combustion from that half, and it is thus possible to maintain a lower uniform stack temperature which is the nearest practicable approach to the theoretical.

Generated on 2024-09-08 16:14 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

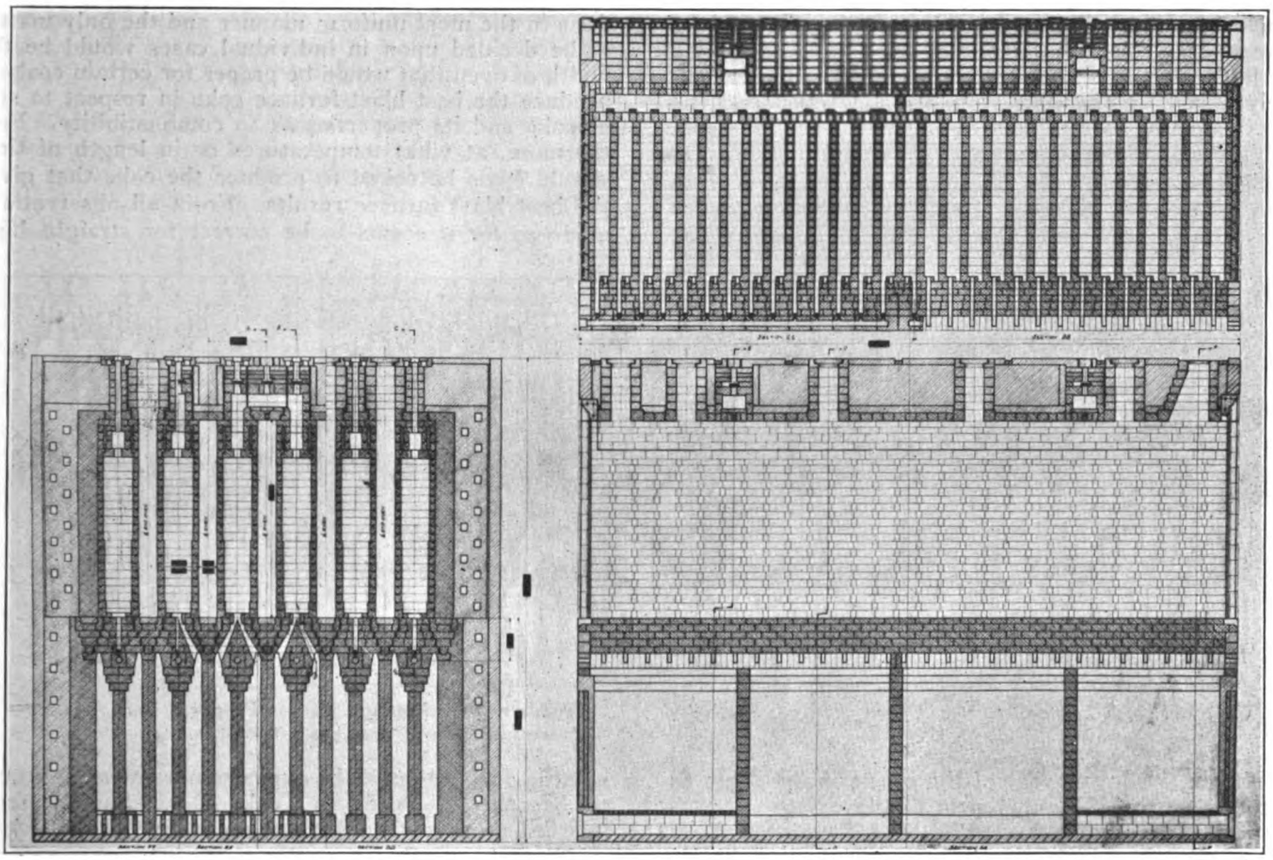


FIG. 11.
Plan and cross section of the new combination oven of the Koppers Company.

Minimum Leakage—No Counterflow.

It will also be noticed when air flows upward in two regenerators that the gas supply flue located in the supporting wall separating these two regenerators is operating also for up-flow combustion while the adjoining heating wall operates for discharge of waste gases and consequently the gas supply flue located in that particular regenerator wall is not in operation. In other words there are hardly any pressure difference between up-flowing regenerators and gas supply flues and consequently the leakage of the gas distributing flue will be reduced to a minimum.

Figs. 12, 13, 14 and 15 show the flow of gases when using coke oven gas and blast furnace or producer gas. Figs. 14 and 15 show the oven when operating on producer or blast furnace gas. When producer gas or blast furnace gas of low heating value is used for heating the ovens, it must be preheated in order to obtain the desired temperature and to operate economically. This preheating is accomplished by passing the gas through separate regenerating chambers on its way to the heating walls. In the new design of oven the arrangement of regenerators and flow of gases is such that there does not exist at any time a counter flow between incoming fuel and out-going products of combustion in adjacent regenerator chambers. Fuel gas and out-going products of combustion are always separated by a regenerator containing in-going air. Should there be a slight leakage into the waste gas regenerator chambers, it would only result in loss of air, while it would be impossible to lose producer or blast furnace gas.

The battery of 5 ovens of this new design at Chicago was operated on 11 hrs. coking time for several months with producer gas having a heating value purposely varied between from 85 to 125 Btu. and it was demonstrated that the oven when heated with this producer gas gave most satisfactory results as to heat distribution and fuel consumption. It was absolutely evident that there was no leakage of producer gas into waste gas on account of producer gas and air flowing in parallel and a counter-flow only existing between air and waste gas.

It has been demonstrated that on the 5 ovens at Chicago the arrangement of regulable ports in that construction is correct for both conditions, that is, when using straight coke oven gas or producer gas. See Fig. 16. The same small temperature difference between top and bottom when using coke oven gas was observed as when using producer gas.

The tests for determining the progression of coking at different elevations in the oven chamber as made at the Providence Plant were repeated with the same instruments and in the same manner on these 5 ovens at Chicago and the results obtained were most gratifying. See Fig. 17. The absence of the interference of the horizontal flue together with the unique design of adjustable air ports gave a distribution of heat in such a way that the entire mass from top to bottom and from end to end was finished at the same time, the difference in temperature usually not exceeding 100 deg. F.

Coke of Uniform Quality and Size.

The coke produced from these new type ovens was

Generated on 2024-09-08 15:51 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

decidedly more uniform than that produced from the older ovens. The large pieces of coke originating near the horizontal flue region of the older oven were entirely absent in the coke from the new oven and the coke from the bottom part of the new oven was just as large as the coke from any other part of the oven.

Shatter tests and combustion tests have been made from coke out of different elevations of the new ovens and it has been found that the combustibility of the coke from the lower part of the ovens is the same as that taken from the upper part of the ovens. It was further shown that the shatter tests from the upper part of the oven are virtually the same as the shatter tests from the coke produced in the lower part of the oven. This indicates that besides very uniform size of coke produced in this new oven, the characteristics of the coke from different parts of the ovens show great uniformity.

In making coke of 11 hours in this new design of oven, the temperature of the flue walls did not exceed the maximum of 2,550 deg. F. and the fuel consumption in coking Pittsburgh coals was equivalent to 1,050 Btu. per pound of coal.

The advantages claimed for this new oven are as follows:

1. Greatest simplicity of design.
2. Perfect distribution of heat in such a way that the coking within the coal charge progresses uniformly at all places, thus preventing any over and under coking.
3. Increased capacity per oven unit.
4. Lowest fuel gas consumption.
5. Maximum strength of oven walls.
6. Lowest pressure differentials throughout the entire oven system.
7. Complete absence of counter-flow between flame flues and gas supply flues and gas regenerators.

All of the above mentioned improvements will guarantee the long life of the oven structure and the continuous supply of most uniform coke at the lowest fuel consumption and operating expense. It should be emphasized that the low draft conditions existing in these ovens is of great importance because it insures long life of the oven. It is a well known fact that high draft conditions in ovens always results in early oven repairs and loss of products.

The foregoing shows that the coking of coal can be done in the most uniform manner and the only matter to be decided upon in individual cases would be the width of oven that would be proper for certain coals to produce the best blast furnace coke in respect to size of coke and its properties as to combustibility. Furthermore, at what temperatures or in length of time should coals be coked to produce the coke that gives the best blast furnace results. From all observations made so far it seems to be correct for straight high volatile coals to build the ovens as narrow as is practical because this produces a coke of less fingery structure and cross fracture than when made in wider ovens.

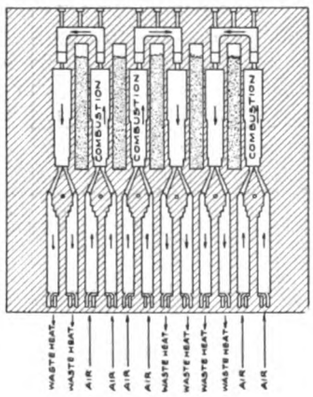


FIG. 12
Coke oven gas heating.

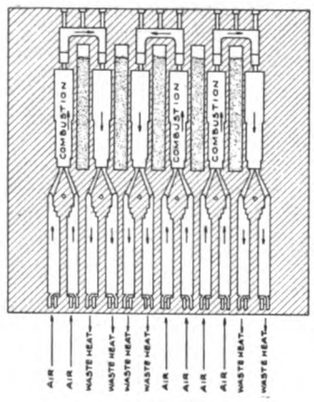


FIG. 13.
Coken oven gas heating—reversal.

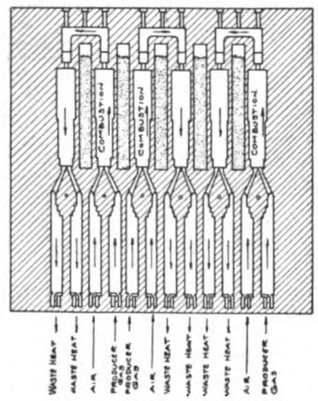


FIG. 14
Producer gas heating.

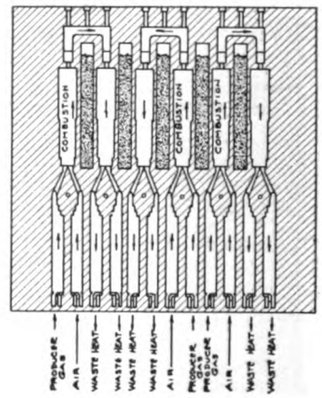


FIG. 15.
Producer gas heating—reversal.

There is usually a variation in the coke starting with the wall side and ending at the center of the oven. This variation is greater in wider ovens than in the case of coke made in narrow ovens. In making tests of a piece of coke and taking samples from the inner end of the coke, the middle and the outer end of the coke, it has been observed that the specific gravity and porosity of the coke changes from center to end, and that in wider ovens the cauliflower and dense end penetrates to a greater depth than in narrower ovens. It has been observed in the coke made in the 5-oven battery at Chicago that a much more uniform porosity was practically maintained from one end to the other of a piece of coke. Coals coked in narrow ovens give a higher yield of tar than when coked in wide ovens, indicating that the smaller yield of tar must have been accompanied by formation of additional gas and residue of carbon which is deposited on the cell walls of

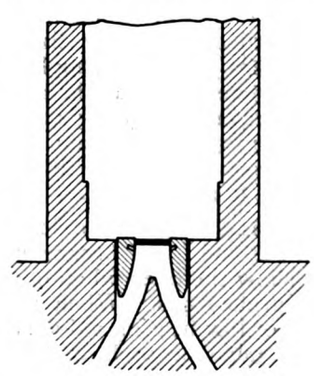


FIG. 16.
Showing the adjustable air port of the new Koppers oven.

Generated on 2024-09-08 15:47 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

the coke. However, carbon coke made from tars is very refractory and combustion tests on carbon coke made from tar subjected to a temperature corresponding to that of coking operation—that is about 1,800 deg. F. showed that the combustibility of such material was decidedly less than the combustibility of ordinary coke. This would again indicate that a given coal when coked under conditions which yield the maximum in tar would produce a coke of greater combustibility than when coked under conditions where the tar yield is relatively low. For these reasons it is advisable to build as narrow ovens in so far as is practicable and consistent with economical operation. Since the time for coking is shorter in narrower ovens, particularly in this new type of oven, the coke is exposed for less time to the detrimental effect of high temperatures which again insures maximum combustibility of the coke, a quality which lately has been emphasized as being most important by men prominent in the coke oven and blast furnace industry.

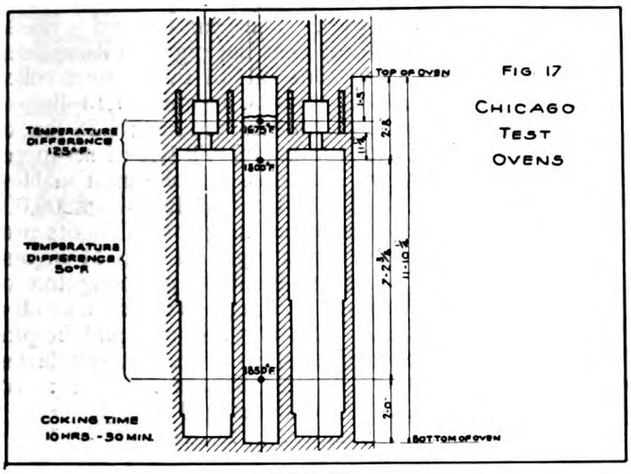


FIG. 17.
A heat progression chart for the new combination oven.

FIG. 18.*
Coke from Black Briar Illinois coal on the coke wharf at the Chicago By-Product Coke Company.

*The subject of making a good grade of blast furnace coke from Illinois coals has been a much mooted one. Large scale oven tests made by the Koppers Company in 1911 showed that Illinois coals would make a good grade of blast furnace coke and subsequent tests made by the Bureau of Standards in 1917 conclusively demonstrated that such was the case. (See Bulletin Bureau of Standards No. 37, entitled, "Coking of Illinois Coals in Koppers Type Oven.") Fig. 18 shows coke from 100 per cent Black Briar Illinois coal, made in the experimental battery of five ovens described in this paper. A large quantity of this coal was coked at the time and the results further demonstrated that not only would these coals coke, but that they made a very excellent grade of blast furnace coke on as short a coking time as 11 hours. Three hundred and sixty-eight ovens of this type are under construction for the Carnegie Steel Company at Clairton and 37 ovens of this type are now under construction for the Weirton Iron & Steel Company at Weirton, W. Va.

Discussion of Heat Balance

A Table Prepared from Prof. Trinks' Article on "Heat Balances in Steel Plants" for Purposes of Comparison and Study.

By J. B. CRANE*

PLANT No. 1. Heat balance of an uneconomical steel plant based on one pound of finished steel. This heat balance is used on 50 per cent scrap, 50 per cent cold pig iron being used in open hearth furnaces. One-half of the product rolled to 1-in. squares, one-half to 8-in. beams. 1.13 lbs. of blooms required per lb. of finished steel; 1.26 lbs. of ingots; 0.675 lbs. of pig iron plus 0.675 lbs. of scrap iron per lb. of finished product. 2,200 lbs. of coke used in blast furnaces per long ton of pig iron produced. 7,000,000 Btu. required in open hearth per long ton of ingots produced; 1,100,000 Btu. in soaking pits per ton of ingots; 4,500,000 Btu. in reheating furnaces per ton of blooms or billets. Mills driven by steam engines, 150 lbs. saturated steam, non-condensing. All auxiliaries steam operated. Steam blowing engines, non-condensing. Beehive coke ovens. (Note: All figures represent Btu. per lb. of finished steel.)

*George T. Ladd Company, Pittsburgh.

Plant No. 2.

Heat balance of an average steel plant. Based on one pound of finished steel. This heat balance is based on 50 per cent scrap, 50 per cent cold pig iron being used in open hearth furnaces. One-half of the product rolled to 1-in. squares, one-half to 8-in. beams. 1.13 lbs. of blooms required per lb. of finished steel; 1.26 lbs. of ingots; 0.675 lbs. of pig iron plus 0.675 lbs. of scrap per lb. of finished product. 2,200 lbs. of coke used in blast furnaces per long ton of pig iron produced. 6,000,000 Btu. required in open hearth per long ton of ingots produced; 1,000,000 Btu. in soaking pits per ton of ingots; 3,800,000 Btu. in reheating furnaces per ton of blooms or billets. Mills driven by steam engines, 150 lbs. saturated steam, 20-in. vacuum. Blast furnace auxiliaries steam operated, all other auxiliaries electrically operated. Electric power supplied by turbo-generator, steam blowing engines and turbo-blowers, 150 lbs. saturated steam,

Generated on 2024-09-08 15:46 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

20-in. vacuum. (Note: All figures represent Btu. per lb. of finished steel.

Plant No. 3.

Heat balance of an uneconomical steam operated steel plant. Based on one pound of finished steel. This heat balance is based on 50 per cent scrap, 50 per cent hot pig iron being used in open hearth furnaces. One-half of the product is rolled to 1-in. squares, one-half to 8-in. beams. 1.13 lbs. of blooms required per lb. of finished product; 1.26 lbs. of ingots; 0.675 lbs. of pig iron plus 0.675 lbs. of scrap per lb. of finished product. 1,800 lbs. of coke used in blast furnaces per long ton of pig iron produced. 4,800,000 Btu. required in open hearth per long ton of ingots produced. 900,000 Btu. for soaking pits per ton of ingots; 2,750,000 Btu. for reheating furnaces per long ton of blooms or billets. A mixture of coke oven gas, blast furnace gas and producer gas is used in reheating furnaces and in pits. Mills driven by economical steam engines, operating with steam at 200 lbs. pressure, 100 deg. superheat, 27-in. vacuum. Blowing engines steam driven, same conditions as above. Blast furnace auxiliaries steam operated, other auxiliaries electrically operated. Electric power supplied by turbo-generators, 200 lbs. steam pressure, 10 deg. superheat, 28-in. vacuum. (Note: All figures represent Btu. per lb. of finished steel.)

	Plant No. 1	Plant No. 2	Plant No. 3	Plant No. 4
Btu. to coking coal	13,260	11,466	9,360	9,360
Btu. to boilers	6,480	2,835	3,358	
Btu. to producers	9,450	5,230	1,132	2,202
Total Btu. for 1 lb. of steel	29,190	19,531	13,850	11,562
Btu. lost in coking coal	6,025	1,780	1,515	1,517
Btu. waste in coking coal		350	298	298
Btu. in tar to open hearth		610	500	500
Btu. to furnaces (CO gas)		1,324	1,085	1,085
Btu. to boilers (surplus CO gas)		189	157	155
Btu. used in smelting slag radiation	2,605	2,583	2,270	2,270
Btu. B. F. gas—waste	465	463	353	353
Btu. B. F. gas—stoves	1,480	1,482	1,132	1,132
Btu. B. F. gas—blowing				442
Btu. B. F. gas—boilers	2,685	2,685	177	177
Btu. B. F. gas—melting			1,873	1,067
Btu. B. F. gas—gas engines				364
Total Btu. in coking	13,260	11,466	9,360	9,360
Btu. lost in boiler	3,210	1,859	956	
Btu. lost in condensers	2,087	979	791	
Btu. to blowing engines	1,511	1,075	640	
Btu. B. F. auxiliaries	640	640	646	
Btu. blooming mills	460	370	405	
Btu. bar and shape mill	714	503	301	
Btu. turbine and miscellaneons	543	283	214	
Total Btu. for power	9,165	5,709	3,953	957
Btu. obtained from B. F. gas	2,685	2,685	177	541
Btu. obtained from coal	6,480	2,835	3,358	
Btu. obtained from CO gas		189	157	155
Btu. obtained from waste heat O. H.			261	261
	9,165	5,709	3,953	957
Btu. lost in producers	2,366	1,308	284	548
Btu. to open hearth	3,935	3,375	2,700	2,700
Btu. to soaking pits	619	563	506	506
Btu. to reheating furnaces	2,530	1,918	1,100	1,100
Btu. recovered from O. H.			261	261
Total Btu. for furnaces	9,450	7,164	4,590	4,854
Btu obtained from coal	9,450	5,230	1,132	2,202
Btu. obtained from CO gas		1,324	1,085	1,085
Btu. obtained from CO tar		610	500	500
Btu. obtained from B. F. gas			1,873	1,067
	9,450	7,164	4,590	4,854

Plant No. 4.

Heat balance of an economical steam plant. Based on one pound of finished steel. The heat balance is based on 50 per cent scrap, 50 per cent hot pig iron being used in open hearth furnaces. One-half of the product rolled to 1-in. squares, one-half to 8-in. beams. 1.13 lbs. of blooms required per lb. of finished product; 1.26 lbs. of ingots; 0.675 lbs. of pig iron plus 0.675 lbs. of scrap per lb. of finished product. 1,800 lbs. of coke used in blast furnaces per long ton of pig iron produced. 4,800,000 Btu .required in open hearth per long ton of ingots produced; 900,000 Btu. for soaking pits per ton of ingots; 2,750,000 Btu. for reheating furnaces per long ton of blooms or billets. A mixture of coke oven gas and blast furnace gas is used for reheating furnaces and in pits. Power consumption includes blast furnace auxiliaries, rolling, cranes, lighting, shears, tables, etc. (Note: All figures represent Btu. per lb. of finished steel.)

STEEL PRODUCTION IN SOUTH AFRICA GROWING

Steel production in South Africa is making considerable progress, according to a report to the Department of Commerce from Trade Commissioner Stevenson, though not as much as had been anticipated.

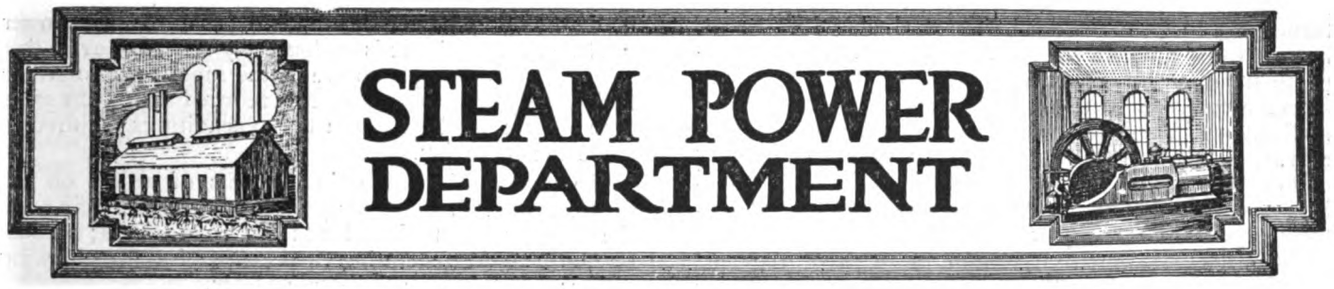
The Union Steel Corporation (of South Africa) Limited, Mr. Stevenson says, is by far the most important factor in the industry, its 1921 production being 14,434 tons of a value of £361,468. The greater part of the output, or 11,573 tons, consisted of open-hearth steel made from scrap materials, while 2,861 tons were made in a 3½-ton Heroult electric furnace. A new 22-inch mill is being installed to roll heavier sections of angles, channels, girders, and similar products from 20 to 30 pounds per foot, and rails up to 60 pounds per yard. A new 25-ton Siemens open-hearth furnace has been erected and when in full working order the capacity of the works will be 30,000 tons a year. The Union Steel Corporation has already supplied a large part of the reinforcing steel contract for the government grain elevators, and has rolled a few rails which have been purchased by the South African Railways for trial purposes.

The Dunswart Iron and Steel Works, Limited, turned out 5,355 tons of iron, valued at £123,165 in 1921. A new 3-roll high 18-inch cogging mill is in the course of erection. It is intended later to manufacture steel castings up to 7 tons in weight.

The Witwatersrand Co-operative Smelting Works, Limited, has erected a new plant at Driehoek, to which the old equipment is being transferred. The capacity of the new plant will be 4,500 tons per annum. The 1921 output was 1,296 tons of shoes and dies, worth £25,900, as against 1,201 tons in 1920, valued at £24,020.

It would appear, Mr. Stevenson concludes, that the local industry has not as a whole made the progress that was anticipated, even allowing for the depression period. Whether the new Iron and Steel Industry Enactment Act will prove sufficiently attractive to interest capital is open to some question.

Generated on 2024-09-08 15:50 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO



The Economic Importance of the Power Plant in the Steel Industry*

By E. F. ENTWISLE†

FROM the inception of the human race, its development has been dependent on its knowledge of and ability to use power. The first manifestation of power was in man's own labor in caring for himself, then in using his power in making others work for him, then the gradually increasing realization that the blowing of the wind, the flow of water, the heat of the fire—all could be used in ways that outdistanced human effort and pointed the way to still greater possibilities of accumulated power. Civilization has progressed as sources and control of power have progressed and today we find virtually every line of human endeavor absolutely dependent on some kind of power not contained within the individual himself, every industry with power the very mainspring of its existence, and in innumerable cases furnished from a source over which the industry itself has no direct control.

From the beginning, the steel industry has had to depend on its own organization for its power, first in human effort in collecting its materials for reduction by natural combustion, then by further human effort applied to the bellows of the Catalan forge, then by the application of water power, by the steam engine and the combustion of natural fuel for steam generation. Afterwards followed the first crude efforts at utilization of waste gases in boilers and blast heating, working up finally to the direct use of the gas in the internal combustion engine, so that with the gradual development of the industry there has been a parallel development in the industry's own power plants.

This has been true of necessity, for at the outset there were no adequate sources of, or means of transporting to the plant, the large quantities of power required, and long before any knowledge of electrical generation and transmission, it was recognized that the sources of power in the industry itself necessitated their utilization at the plant, so that we have today in every steel works a power plant, frequently in many units, generating in all of its several phases most of the power required to carry on the various operations from raw materials to finished steel products.

During comparatively recent years tremendous development has been made in the size, reliability and control of electrical apparatus for steel plant service and in the generation and transmission of the power required for its operation. Its almost innumerable applications need no recapitulation here, but they have been so general in character and large in total that in many cases the development of the plant's own power supply has not kept pace either in economy or size with the peak power demand, so that electric current frequently must be purchased to take care of these maximum load periods. It is only natural to expect that still further applications of power, both electric and steam, will be made in the ever constant development of the steel industry so that its power plant will ever become increasingly important.

How large a factor any one item is in steel manufacture is judged mainly by its percentage of the cost of the finished product. Knowledge of operating costs is essential to economic operation, and the steel plant cost sheets of the present day furnish the executive with the detailed information that enables him to analyze production costs. Every item, raw materials, labor, repairs, transportation, etc., and their relative importance to each other for various products, is constantly before him, and his mind is always concerned in cost betterment, either through rendering labor more efficient, through price reductions, substitution of less expensive or of better materials, or through more economical use of the materials available. Unfortunately, power does not appear on our cost sheets as a single total item and we are apt to think of power costs only to the extent that they do appear as separate items of steam, electricity, water and air, not always remembering that power is the total of all of these, plus the additional power costs that are necessarily included in our cost sheet figures, in raw materials for their handling, in partly worked materials, power for shops appearing as repairs, and many other auxiliary operations.

The result is that the true cost of power is not generally fully appreciated, total power cost being defined as the cost of producing or purchasing all the energy for generating steam, electricity and blast furnace blowing. In such a cost, waste heat must be accorded a value commensurate with the value of the fuel that would have to replace it if the waste heat were not available. While it is true that the value placed on such waste heat is re-

*Paper read before the American Iron and Steel Institute, at New York, October 27, 1922.

†Assistant General Manager, Steelton Plant, Bethlehem Steel Company, Steelton, Pa.

Generated on 2024-09-08 15:46 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

turned as a credit to the cost of the producing department, its real value must be set down as an item of power expense in order to fully appreciate how large an item power actually is in production costs and for a proper realization of the importance of its economic use. However, it is also important to know what portion of power costs occurs from such waste gas and heat charges, and it is advisable that these charges be so accumulated that their effect on costs can be properly judged.

The data submitted has been taken from the cost records of three of Bethlehem's steel plants and covers the period from January 1, 1920, to August 1, 1922. It is felt that this period is fairly representative of modern practice, 1920 being a year of good production, but with many war time prices and practices still continuing, 1921 being a year of low production and best possible economy, and 1922 being a period of increasing production with a continuance of improvement in the economies of 1921.

	Including value of By-Product Gas and Waste Heat.		Not including any value for By-Product Gas and Waste Heat and with Total Power Consumption figured at Plant producing cost.	
	A	B	A	B
1. Ratio of total power cost to delivered cost of all coal for coking	.82	.60	.60	.28
2. Ratio of total power cost to delivered cost of all gas coal, and oil	1.67	.64	1.22	.30
3. Ratio of total power cost to delivered cost of all ore	.65	.60	.48	.28
4. Ratio of total power cost to delivered cost of all limestone	5.35	2.40	3.90	1.10
5. Ratio of total power cost to delivered cost of all alloys	2.45	2.16	1.80	1.00
6. Ratio of total power cost to delivered cost of all refractories	2.70	2.98	2.00	1.40
7. Ratio of total power cost to total ingot cost	.138	.142	.101	.065
8. Ratio of total power cost to total plant payroll	.255	.230	.187	.106
9. Ratio of total power cost to sales value of all finished products	.071	.080	.052	.037
10. Horsepower hours consumed per ton of shipments	286	242	286	242
11. Kilowatt hours (including equivalent of blast furnace blowing) consumed per ton of shipments	256	516	256	516
12. Per cent of blast furnaces blown by gas engines	100	100	100	100
13. Per cent of Item 10 generated by waste products	39	68	39	68
14. Per cent of Item 11 generated by blast furnace gas	78	72	...	...

It is not necessary to repeat here the individual power consumptions for various products, as we are interested primarily in accumulated power usage and cost. The following tabulation shows the ratio of the cost of total power generation to the costs of some of the principal and more familiar items entering into production costs. From these figures have been eliminated all the effects of such pig iron and coke as were manufactured for shipment to outside customers, so that the data applies generally to any steel plant, the operation of which extends from coke ovens to finished steel products. In the first set of figures, blast furnace and coke oven gas and waste heat are charged to costs at full value. In the second block, all charges for such waste heat products have been eliminated and all power purchased is assumed to have cost the same as the power generated at the plant.

The importance of power as an item in production costs is sufficiently apparent from the preceding tabulation. Any single cost item that, stripped of all credits, reaches the proportion of nearly one-fifth of the total plant payroll, or 5½ per cent of the total sales value of all manufactured products, or twice the cost of all refractories, commands attention. How to reduce it, and the extent to which it can be reduced, constitute the real economic question. Every plant is a problem in itself, and no definite formula can be laid down that is applicable to all. Different kinds of products, different degrees of finish, different seasonal demands and many other variables are considerations that necessarily must be taken into account in determining how much and in what manner power shall be generated. It is undoubtedly true, however, that comparatively few plants are in the same position where their total power costs cannot be reduced and at the same time show a good return on the expenditures required to make the reduction.

In general there are three points of attack on the problem after the cost analysis has been made; first, on the prime movers of mill and auxiliary drives; second, on the electric generating and blast furnace blowing plants; and third, on the steam plants.

Prime Movers for Main Drives and Auxiliaries.

For new installations there is little room for argument against electrification as showing the greatest economy. For existing steam-driven units practically every case will show a fair return on the investment by the substitution of electric drive, including the generating equipment. Some improvement can often be shown by the substitution of more economical types of steam drives, but aside from other considerations, it is obvious that the tremendous handicap of the miles of steam piping required for a steam operated steel plant imposes a burden on the steam drive which it cannot carry in competition with the electric drive.

The Electric Generating and Blast Furnace Blowing Plants.

It is not contemplated in this paper to discuss the relative merits of the types of drive for this service. Sufficient to say that, in general, steel works have not taken full advantage of the economies possible. The power plants are often scattered in a number of separate installations and the overall efficiency of all power generation is not nearly the possible maximum. Usually the maximum operating load can be carried only by putting uneconomical units into operation, or by purchasing power from an outside source.

Steam Plants.

Here can usually be effected the greatest economies and greatest savings. Steam plants are even more scattered than the electric generating plants. They are nearly always old and in small capacity units. It is probably safe to state that 80 per cent of steel works blast furnace gas fired boiler plants have no legitimate excuse for existence, and many of the coal burning plants are but little better. Steam lines should be eliminated

Generated on 2024-09-08 16:14 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

wherever possible, and where they must exist, should have the fullest protection and attention to minimize condensation and leakage losses.

Keeping these three general points in mind it is interesting to return momentarily to the tabulated figures, particularly items 7 to 14, inclusive, as they illustrate to some extent the possibilities referred to.

A is the average of plants in which power requirements are about evenly divided between steam end electricity, while B is a plant which is, primarily, motor driven. While the nature of the products from plant B requires nearly twice the quantity of power per ton than do the products from A, B's power bill per ton is scarcely greater than A's, due to its more extensive recovery of power, proportionally, from its by-product gas and waste heat, and in spite of the fact that 28 per cent of its total electric power must be purchased at a unit cost of about four times its own generating cost, all of its own power being generated by gas engines. Plants A purchase 14 per cent of their electric power consumption. Improvements now under way at B will eliminate this excess burden, and a truer comparison of the accomplishment possible may be seen in the second block of figures, in which gas and waste heat charges have been eliminated and the power now being purchased figured at plant producing costs.

Further reductions in this plant's power costs may be made through the replacement of its existing boiler plants, and it is safe to say that this plant, or any one similar in equipment and power requirements, can reduce its total power bill, eliminating all charges for by-product gas and waste heat, to about 5½ per cent of its total ingot cost.

Returning to the general question of economic importance of the steel works power plant, there are a number of still unmentioned items that must not be overlooked. The investment necessary to accomplish the savings that are shown to be possible by such a detailed analysis is very often a large one and very often the amount is so large that the same investment in added steel capacity, or a different line of product, will yield a larger return than will the power plant. Such a condition very often occurs, and where expenditures must be limited, the power plants have suffered in consequence. It must be borne in mind, however, that every plant addition increases the power plant's responsibility, and while the return may not be of the highest, it is sufficiently attractive to warrant the expenditure, and economically the right thing to do.

The power plant is linked economically with the utilization at highest efficiency of all the by-products of the industry and the plant that strives only to utilize sufficient of its energy producing by-products to carry its own power load is looking backward, not forward. Electric power has become of such tremendous importance to the every-day life of our country and its uses are constantly multiplying to such an extent that probably none of us fully realize the power demands of tomorrow. Our country's general system of power generation from coal mine to delivered power has an inefficiency that cannot indefinitely be tolerated, and we are undoubtedly not far from the day of the super-power transmission system, possibly under public service control similar to our rail transportation systems, and under which no industry with power producing by-products may escape the responsibility of contributing them to the general power system. Such an institution will ultimately result in economies to all industry, in reduced cost of power, and to the steel plant particularly, in solving the problem of the best means of supplying the widely separated peaks in both directions, of power demands and supply. Public interest in smoke prevention simply as a convenience has forced economy on many an industry, and the power situation of today offers a similar opportunity, but with the additional weight of public necessity rather than mere convenience.

We cannot help but realize that steel plant operation cannot be, and is not, carried on under the wasteful methods that were common practice not so many years ago. We acknowledge our responsibility in the happiness and welfare of our employes, we acknowledge our responsibility in the economic structure of our immediate communities and of the country, and we cannot be blind to the fact that the not far distant future will impose on us, and rightfully, the problem of converting at highest efficiency all of our waste products into power, to the end that all industry may be benefited by the surplus power thus made available and protected by the resulting conservation of our natural fuel supply.

BRIER HILL STEEL COMPANY PLANS

Engineers of the Brier Hill Steel Company, Youngstown, are continuing their study of the company's expansion program, and directors have not yet approved any program. In addition to adding lap weld tube mills, the company is likewise considering the construction of butt weld units. The lap weld planned will roll pipe from 2 to 12-in. in diameter, though the company has considered units capable of rolling 16-in. pipe. Skelp for these mills will be furnished from the 132-in. plate mill, for the larger sizes, and from a new strip mill, which is to be added, for the smaller sizes.

According to plans now in process, butt weld units may be added to produce wrought iron pipe, absorbing part of the output of the Youngstown Steel Company at Warren. Interests of the Brier Hill company control the Youngstown Steel Company.

REPORTS ON ACCIDENTS IN STEEL INDUSTRY

Accidents in the iron and steel industry decreased materially in 1919 over the previous year according to a report recently issued by the United States bureau of labor statistics on "Causes and Prevention of Accidents in the Iron and Steel Industry, 1910-1919." According to this report the number of accidents decreased in 1914-1915 over 1913 due to the decline in the number of men employed. Employment was increasing from May, 1915, to December, 1917, the accident rate for the same period showing an incerase. A decline started at this time and was in progress at the close of 1919.

Each of the chief causes of accidents, such as machinery, falls, etc., are presented in such a way as to show clearly the relative conditions in the various departments. Considering machinery as a cause of accident, it was found that the electrical department stands at the head of the departments in which there were injuries. The open hearths were second and the fabricating department third under this classification. It was also found that under the classification of hot substances and falls of workers, the electrical department stood first in the number of accidents.

The report also contains a discussion on method to be used by the safety man in the prevention of accidents.

Generated on 2024-09-08 15:52 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

Underfeed Stokers Burn Low Grade of Coal

Underfeed Stokers Specially Designed to Burn Low-Grade Fuel Installed Under 5,600 Sq. Ft. of Boilers—Plant Operates at High Rating and High Efficiency.

By C. E. REESE†

THE boiler plant of the Sixth Avenue Generating Station of the Twin City Rapid Transit Company, Minneapolis, Minn., contains twenty-eight 5,560 sq. ft. boilers, all originally fired with chain-grate stokers and burning a low grade fuel.

This station supplies current to an electric railway system and operates in parallel with several hydro-electric plants which are kept constantly loaded to the limit of the available water supply, consequently this station is required to take care of the stand-by and the wide fluctuation in the railway load, which makes the requirement somewhat severe in both capacity and efficiency incident to the demands of a station operating on this class of service.

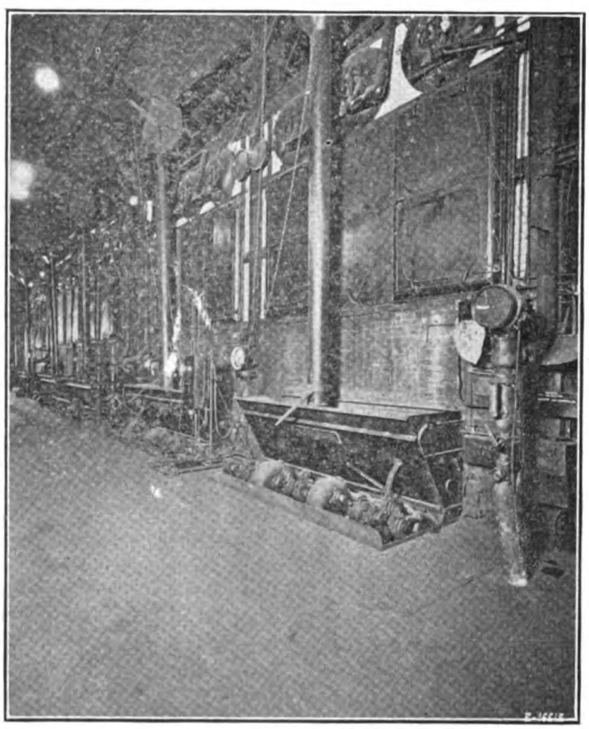


Fig. 1—Boiler room firing aisle.

Several years ago it was decided to increase the capacity of the boiler plant and to improve its flexibility and economy. In view of the kind of coal being used, considerable doubt was expressed at the possibility of accomplishing the desired result with any type of underfeed stoker then available, for the problem of continuous and satisfactory combustion of clinkering coals of low grade, high in ash, moisture and sulphur, had not up to that time been completely solved.

The increase in capacity was, however, successfully accomplished by redesigning the setting of six boilers and replacing the chain-grate stokers with specially designed ones of the underfeed type and has made possible the operating of the boiler up to 350 per cent of rating, thereby materially increasing the capacity of the boiler plant.

The boilers on which the alterations were made are B. & W. water tube, 13 tubes high, 21 tubes wide and of 5,560 sq. ft. heating surface with 900 sq. ft. superheating surface and no economizers. The stokers installed are Westinghouse six-retort underfeed, 10 ft. 8¼ in. in width, 10 ft. ⅞ in. in length, set flush with the boiler front. As the bottoms of the front tube headers are only 8 ft. above the floor line, it was necessary to set the stokers 3 ft. below the floor level to secure the desired furnace volume of approximately 1,300 sq. ft.

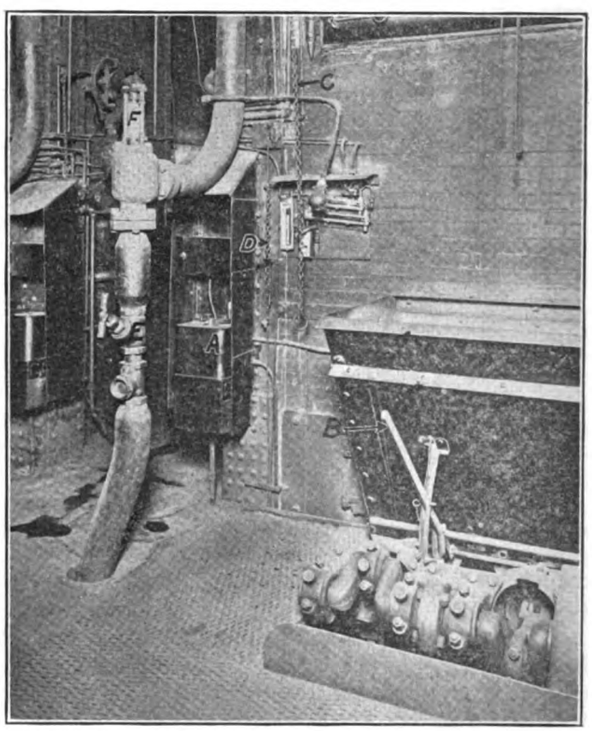


Fig. 2—Control equipment. A—Stoker speed controller. B—Lever regulating length of stroke of secondary ram. C—Uptake damper control. D—Forced draft control. E—Feed-water valve. F—Feed-water flow indicator.

The steam conditions at which the boilers operate are 190-lb. gage and 100 deg. F. superheat at nominal rating.

*Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

Generated on 2024-09-08 15:46 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

Stokers of Special Design.

For the proper combustion of the low grade fuel used, several new features were developed and incorporated in the design of the new stokers. The fuel as it is introduced from the retorts by the rams is spread laterally by deflecting plates so as to cover the surface of the tuyeres. The action of these plates also loosens the fuel which, when containing large percentages of moisture and dirt, becomes densely packed under the action of the rams. Secondary step-shaped rams, located midway between the deflector plates and the grate tuyeres, insure a continuous movement of the fuel bed. These rams under independent control extend their action practically to the dump grate, filling in blow holes which may start and also building up the fuel bed to a uniform thickness. Thus the auxiliary rams furnish means for controlling the distribution of coal over the fuel bed and for agitating slightly the lower fuel bed. At the same time all grate surface is made effective for combustion. Thus it is seen that a fuel bed of uniform thickness is made to travel steadily toward the rear. In practice the stoker has been found to maintain these conditions.

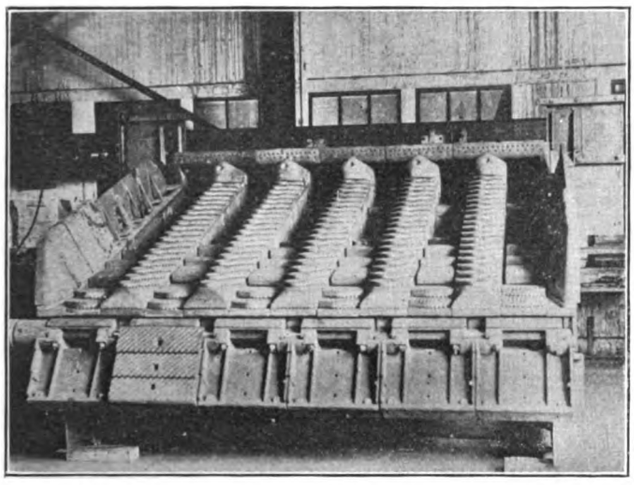


Fig. 3—View of stoker in course of erection.

Adjustment of Secondary Rams.

The length of the stroke of the secondary rams is regulated by one adjustment lever. On the upper end of the auxiliary ram driving rod is a block with four notches, which is engaged by a pin driven through a fixed stroke by a series of links from the primary ram. According to which of the four notches the pin engages, the lost motion of the link movement is taken up so as to vary the stroke of the secondary ram from zero to 6 in. The control of the lost motion is effected by the use of a selector block which slides under the pin and prevents it from engaging any but the desired notch. The details of this construction are shown in the cross-sectional view of the stoker.

To protect the front and side walls adjacent to the fuel bed and prevent the formation of clinkers at this point, extension tuyeres were used. These extend approximately to the top of the fuel bed. Both the side-wall tuyeres and front-wall air boxes admit a limited amount of air underneath and near the surface of the fuel bed, tempering the gases and forming a cool blanket over the lower furnace walls. The reduced temperature in that region is helpful in protecting the brickwork. A battery of high-velocity steam jets placed in the front wall about 18 in. above the fuel bed surface and directed parallel to that surface, insures complete combustion by thoroughly mixing the gases before they enter the tubes. These jets also divert the gas flow toward the back wall of the furnace, providing for a sweep of the gases over the full length of the exposed boiler tubes.

For the discharging of clinker and ash at the rear end of the grate, duplex dump plates are provided, one of which is hinged to the lower end of the stoker and the other to the rear wall support. Each is actuated by an individual steam ram located on the outside of the boiler setting. The stroke of these rams can be controlled by the setting of a collar on the piston. The front dump grate, by its lifting action, may be used to break up clinkers as they pass to the rear dump and also to hold back the fuel bed when the rear dump is dropped. Air for combustion is supplied under control to both front and rear dump grates. This auxiliary air supply enters through a duct enclosed in one of the steel members that support the lower end of the bridge wall. The entire grate surface thus becomes active when required and the carbon is burned down to a low percentage of the refuse before dumping. Also ashes may be dumped frequently on heavy loads without interfering with the output or efficiency, and refuse is disposed of before it builds up into large clinkers.

Changes Made in Baffling.

With the increase in boiler capacity that would be obtained by the installation of the underfeed stokers, considerable change was made in the boiler baffling. It was designed to give practically a constant gas velocity by increasing the cross-section of the passes in the same ratio that the gases contract due to the abstraction of the heat by the tubes. The bridge wall and baffling are so located as to expose 90 per cent of the tube length, giving a tube area double that of the grate to absorb heat by the direct radiation from the fire. The bridge wall rises from the dump grate to a level with the surface of the rear of the fuel bed and then recedes to the rear, meeting the tubes at the back end of the boiler. With this condition of tube exposure, it is estimated that over 50 per cent of the total heat is absorbed in the first two rows of tubes. The high heat absorption directly by radiation accounts largely for the low furnace temperature and consequently a minimum of clinker formation. Before dropping on the bucket conveyor, the ashes must pass through an 8x8-in. cast iron grid. If

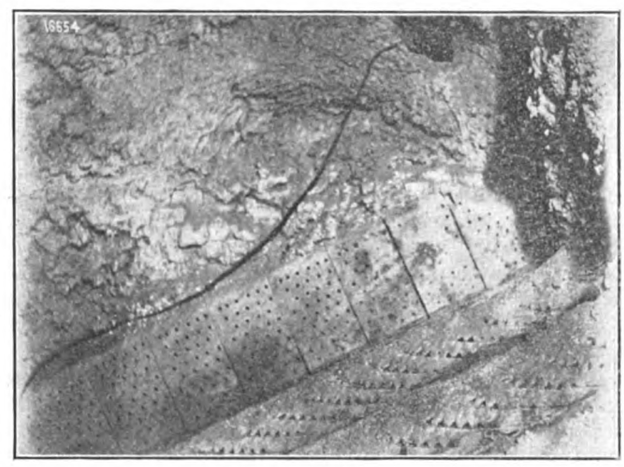


Fig. 4—Showing side wall tuyeres.

Generated on 2024-09-08 15:49 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

there was excessive clinkering, this system would be objectionable because the refuse would have to be reduced to the proper size before it could be handled by the conveyor.

With the installation of the new stoker and the redesigning of the furnace, the angles of the stoker, the front and bridge wall are so arranged that the radiant heat which does not enter the tube surface directly

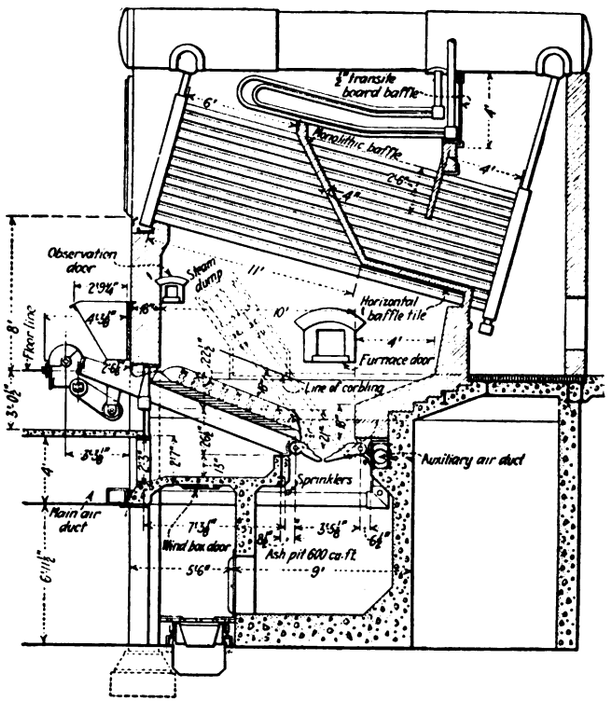


Fig. 5—Section showing details of stoker.

reaches the boiler with but one reflection. Such a condition means that the maintenance of furnace walls and other brickwork is considerably lowered by the elimination of double and triple reflections. After 18 months' operation the furnace settings have required no repairs of brick linings and there is practically no accumulation of slag on the walls.

The area of the superheater surface was increased approximately 63 per cent, as it was estimated that the temperature of the gases as they entered the second pass would be considerably lower than formerly, owing to the heat absorbed directly from the fuel bed by the first two rows of tubes, and to the change in the baffling. The superheater, consequently, was lengthened so that the bends extended over the first pass instead of merely up to the first baffle. This gives the effect of a double-pass superheater. Its area was increased from 550 to 900 sq. ft. by this extension to be sure that at least the same superheat would result. When operating at about 170 per cent of rating, the superheat formerly averaged about 100 deg. F. and the chart, Fig. 6A, shows how it was increased to 140 deg. F. at this rating and also how it continued to increase as the boiler was forced to higher ratings.

The construction of the rear baffle as worked out made it unnecessary to utilize the superheater headers to support the baffle tile. Instead of baffle tile in that position, between the lower superheater headers and the boiler drums, ½ in, Transite board has been used. It is secured between two "L" holders, the upper one being hung from ⅞-in. rods passing over the boiler drums. The lower one is built into the section of tile baffling resting on the upper rows of boiler tubes. Seven sections, 21 in. by 4 ft., are required per boiler, each section being reinforced vertically with an angle and a channel. The advantage of this type of construction is that the baffling is readily removable and that it is independent of the expansion and contraction of the superheater risers.

By referring to the boiler record chart, Fig. 7, it will be seen that the equipment has demonstrated the possibility of operating at any capacity up to 350 per cent

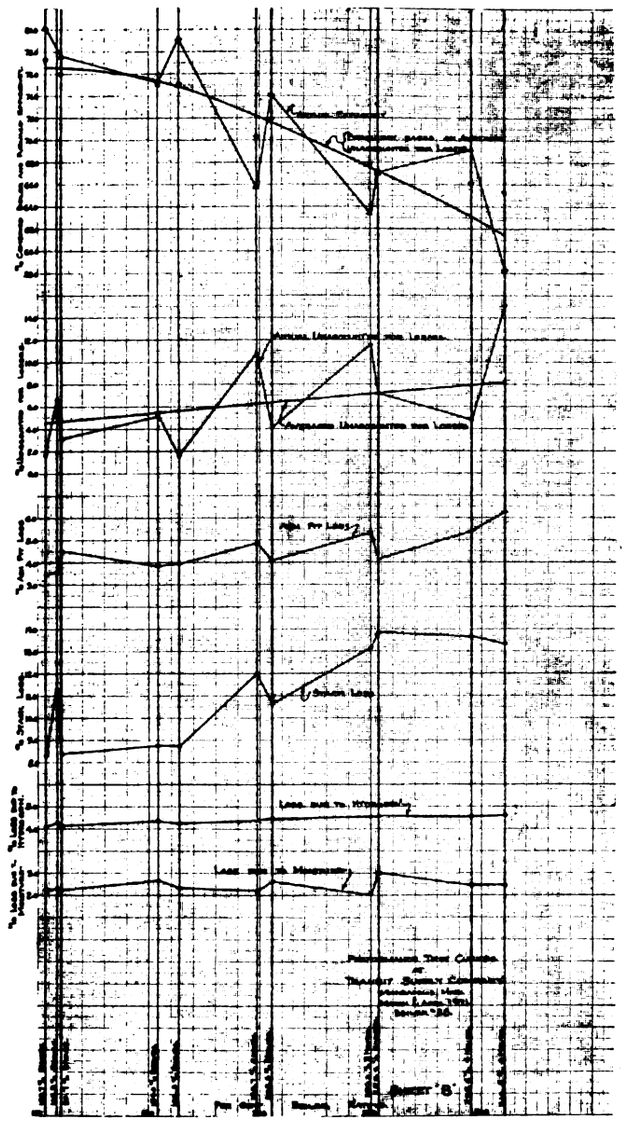


Fig. 6—Performance test curves at 100 to 350 per cent rating.

of rating. At this high rating low grade fuel is burned at a rate of one ton per retort per hour, and the refuse is disposed of with no excessive loss of carbon or loss of capacity or efficiency while dumping. Whether this high rating is the limit of the stoker capacity has not yet been determined, for the rate of evaporation was limited by the capacity of the feed pump and the feed line to supply the boiler with water.

This design of stoker and furnace has demonstrated other advantages. It is possible to control the air supply

Generated on 2024-09-08 16:01 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

to the most efficient proportions, little if any slag is formed on the furnace wall, and the highest efficiency is secured at or near normal rating. The stoker maintenance has been low and the percentage of combustible in the ash has been reduced to a negligible proportion.

In Fig. 6 are shown the curves that were obtained from a series of 12 tests, at outputs ranging from 100 to 350 per cent of rating, conducted under the direction of E. H. Scofield, engineer of power, and by representatives of the Westinghouse Electric & Manufacturing Company and of the Twin City Rapid Transit Company. The fuel characteristics and operating conditions varied as outlined in the following tabulation, the result of each test being reduced to a basis of conditions shown in the third column:

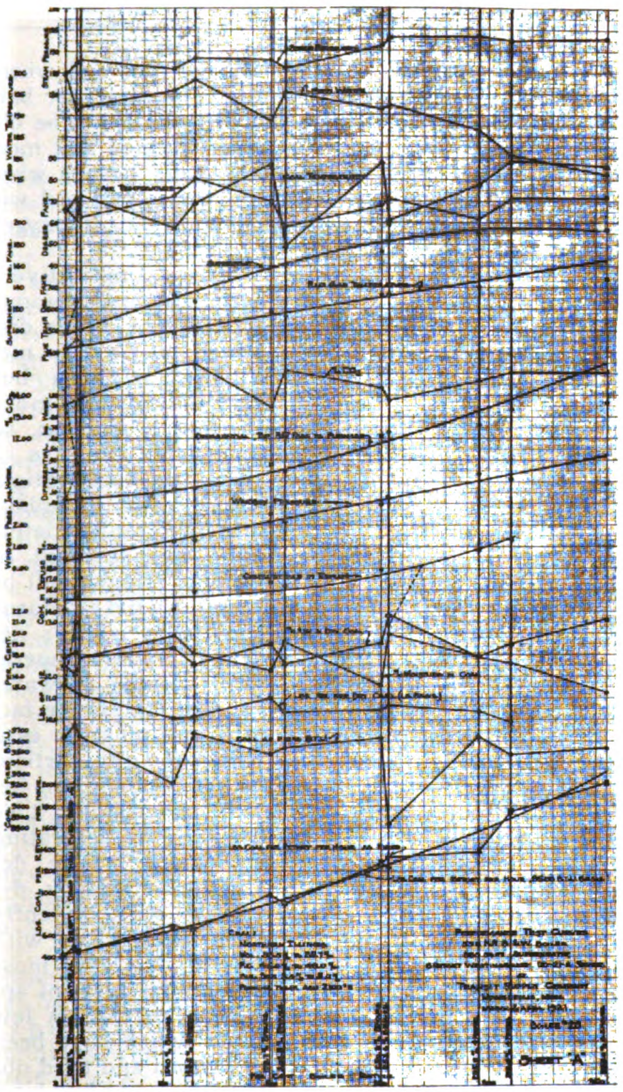


Fig. 6A—Performance test curves at 100 to 350 per cent rating.

Coal—	*Minimum*	*Maximum*	*Curve Basis*
Moisture, per cent	14	20	18
Ash, per cent	16	22	18
Sulphur, per cent	3.5	5	4
Volatile, per cent	32	35	33
Fixed Carbon, per cent	45	48	45
Ash fused, at deg. F.	..	..	2100
Btu. commercial	8827	9750	9550
Btu. dry	..	..	11650
Btu. combustible	..	..	14200
CO_2 at top of third pass, per cent	13.5	15.5	14–15
Carbon in refuse, per cent	13.0	20.0	15–20
Uptake temperature, deg. F.	415	740	400-750

While the efficiencies on test range from 77 per cent at normal rating down to 60 per cent at 350 per cent of rating, the average operating economy is placed at about 70 per cent. Considering the wide and sudden variations in load and the character of the fuel, this performance is excellent. It may be compared to an average of 60 per cent for the old installation.

That considerably better results can be expected with a higher grade of fuel was indicated by four tests made at loads ranging from 200 to 275 per cent of rating with Harrisburg screenings of the accompanying analysis. The results are indicated by the squares in Fig. 6.

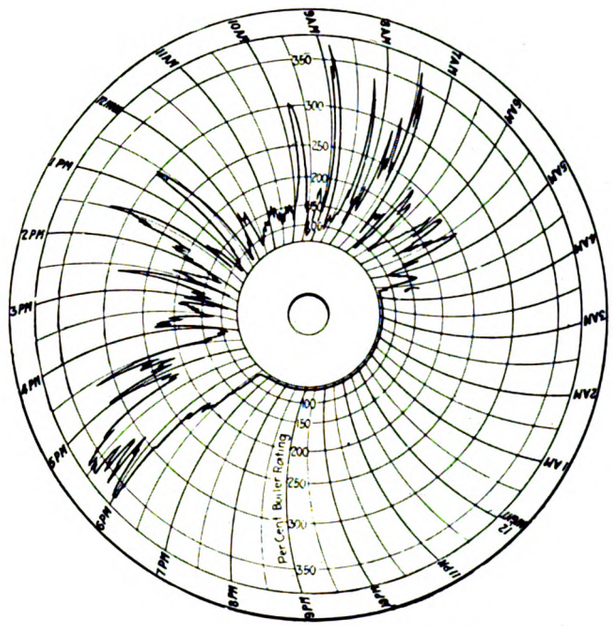


Fig. 7—Per cent boiler rating developed.

ANALYSIS OF HARRISBURG SCREENINGS

Combustible	77.87
Moisture	9.90
Ash	12.23
Volatile—dry coal	29.48
Fixed carbon	54.11
Sulphur	2.81
Ash	13.60
Btu. commercial	11,304
Btu. dry coal	12,541
Btu. combustible	14,514

During the 12 tests no large clinkers were formed at any time, no slice bar work was required on either side wall or bridge wall, and no slag formed on the furnace walls or boiler tubes. The dumping periods were frequent and there was no appreciable drop in the percentage of CO_2 or in the steam flow. Such furnace conditions provide a unit of great flexibility peculiarly adapted to stand-by and intermittent demands and to meet the most exacting requirements of railway and power loads. They also reduce the banking losses to a low figure, the amount consumed during banked period being around 250 lbs. per boiler hour.

Generated on 2024-09-08 15:48 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

Corrosion Control by Deactivation of Water

Relative Rate of Corrosion—Protective Coatings—Dissolved Oxygen in Water—Oxygen Removal by Chemical Means.

By FRANK N. SPELLER,* B.A.Sc., Member A. S. M. E.

PART II

TWENTY or more of such plants have been put into operation to protect the hot-water systems of large buildings in the United States during the past two years. There is no practical difficulty that has not been overcome in operating such plants. The residual oxygen may vary from zero to about .75 c.c. per litre during certain parts of the day without doing perceptible damage. It is more difficult to remove the last traces of oxygen which in any case have a negligible influence from a practical standpoint, but when the rate of flow slows down, the oxygen is more completely removed and a large volume of deactivated water is thus available for use at any time. So far, experience indicates that the metal should be removed from the deactivating tank every two or three years, depending on the demands of the system. That which has been only partially consumed may be cleaned and put back with new sheets. Domestic water carries on the average for the year 10 p.p.m. of oxygen by weight which will consume about 0.2 pounds of iron per 1,000 gallons, which represents a saving of that much iron in useful form in the more inaccessible parts of the plant.

Deaeration By Mechanical Means.

Experimental work on oxygen removal at low pressure and high temperatures with which the author has been associated, usually gave an oxygen content lower than the theoretical figure, due to corrosion of the apparatus. With sufficient time and where the water is broken up by spraying or passing over baffles, the theoretical minimum oxygen can always be obtained. Many tests in service have indicated that most of the common types of open feed water heaters when properly vented and operated without excessive load will give approximately the theoretical minimum of oxygen as indicated in saturation curves (Fig. 1).*

It is a comparatively easy matter to remove 80 per cent of the dissolved gases by mechanical means but very difficult to remove the last 5 per cent, so that, as in the case of chemical deactivation, before designing a plant it is important to determine what amount of residual oxygen will be harmful under stated conditions. This depends on the temperature, volume of water handled, and other factors, and must be estimated for any particular set of conditions before undertaking the design of deaerating equipment. The deaerating efficiency desired will evidently have much to do with determining the most economical form of apparatus to use. A few types which have been developed and tried out will be described briefly.

Deaeration of Hot Water.

A simplified form of deaerator, developed by the Anti-Corrosion Engineering Company of

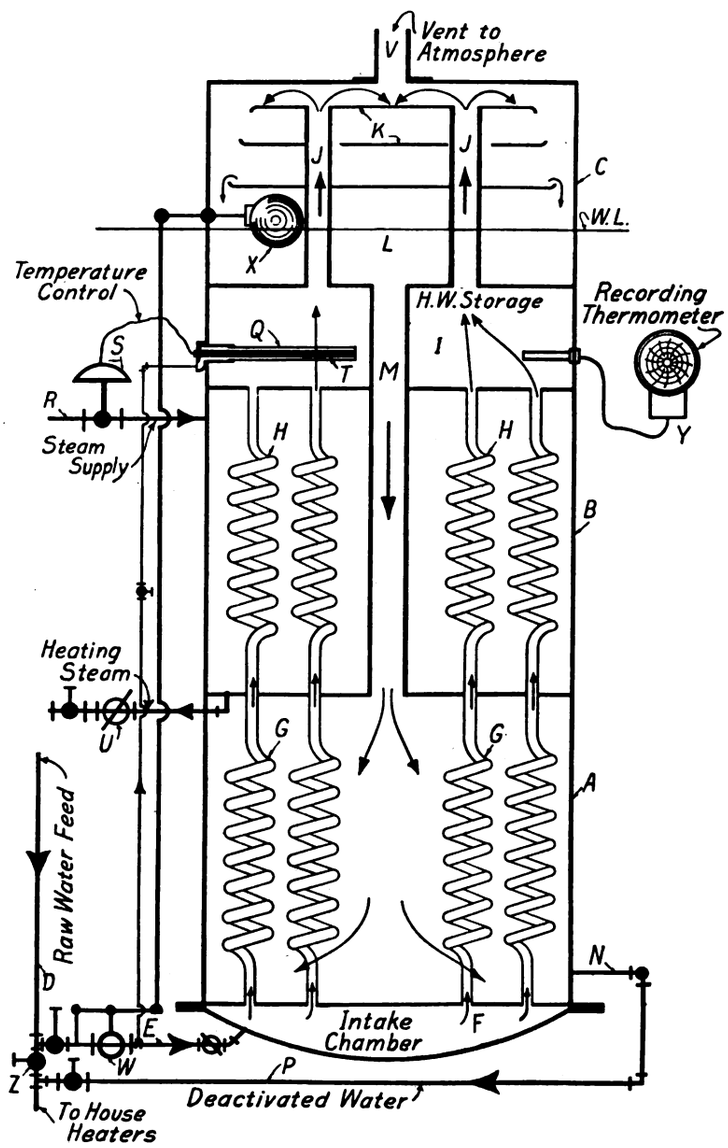


Fig. 9—Deaerator operating at atmospheric pressure.

*Communication to the Franklin Institute.

*The Author is indebted to Mr. G. H. Gibson of the H. S. B. W.-Cochrane Corporation, Philadelphia, Pa., for considerable data on this point which were obtained from heaters in operation.

Generated on 2024-09-08 15:49 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

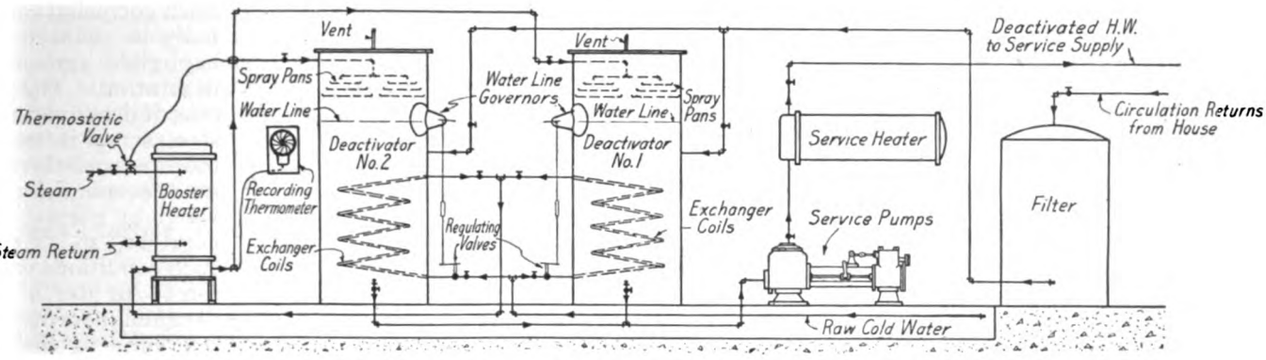


Fig. 10—Deaerators—Passyunk Central Heating Plant, Philadelphia, Pa. (Designed by Anti-Corrosion Engineering Co.)

New York, is shown in Fig. 9. This operates at atmospheric pressure and consists of three essential parts which may be combined in one shell as indicated in Fig. 9. These are: A heater, heat exchanger, and deaerating chamber. An ingenious method of temperature control is provided which is desirable for efficient operation so that the temperature will not vary more than 3 or 4 degrees from 208 deg. F. at any time.

The cold water entering at the point shown near the bottom of the apparatus is partially heated in passing up through the tubes of the heat exchanger by the warmer water coming down. After leaving the heating section, the temperature of the water will be about 208 deg. F. After passing oven baffles of the vented deaerating chamber at this temperature, the oxygen contents are found to be reduced to about 0.4 c.c. per litre, which may be still further reduced by passing through zinc scrap or other deactivating material if desired. Usually, however, this is not necessary.

Several of these plants have been installed in large buildings and appear to be fulfilling their purpose in a satisfactory manner. This method of removing free oxygen has been designed from experience in high buildings which obtain their water pressure from open stand-pipes placed at a high level. The same scheme has been adapted to cases where the hot water is repumped and recirculated as in the plant installed for the Girard Estate Passyunk Power Plant, Philadelphia, Pa. This plant was described by Robert Hughes, Chief Engineer of the Girard Estate.* It includes a hot-water service system for 500 houses to which the water is pumped through a four-inch wrought pipe with a three-inch return loop. The piping was so badly damaged and clogged by corrosion after 10 years that it was decided to try deaeration. A plant was installed in 1920, on the principle of that shown in Fig. 9, except that the heater was independent of the deaerator and heat exchange units. This plant is illustrated diagrammatically (Fig. 10). The temperature is kept within a range of 194 deg. to 210 deg. the oxygen being thereby reduced to a maximum of 0.5 c.c. per litre. They report that corrosion has been brought under complete control and the old rust and scale in the piping removed to a large extent. The removal of the hard rust after the oxygen contents of hot water have been reduced at about 0.5 c.c. per litre is a very interesting and unforeseen development which was observed in the first deactivating plant installed by the author in 1915. The disintegration of this old rust is perhaps due to dehydration or may also be due to a reduction of some of the ferric hydroxide to a lower hydroxide which is more soluble.

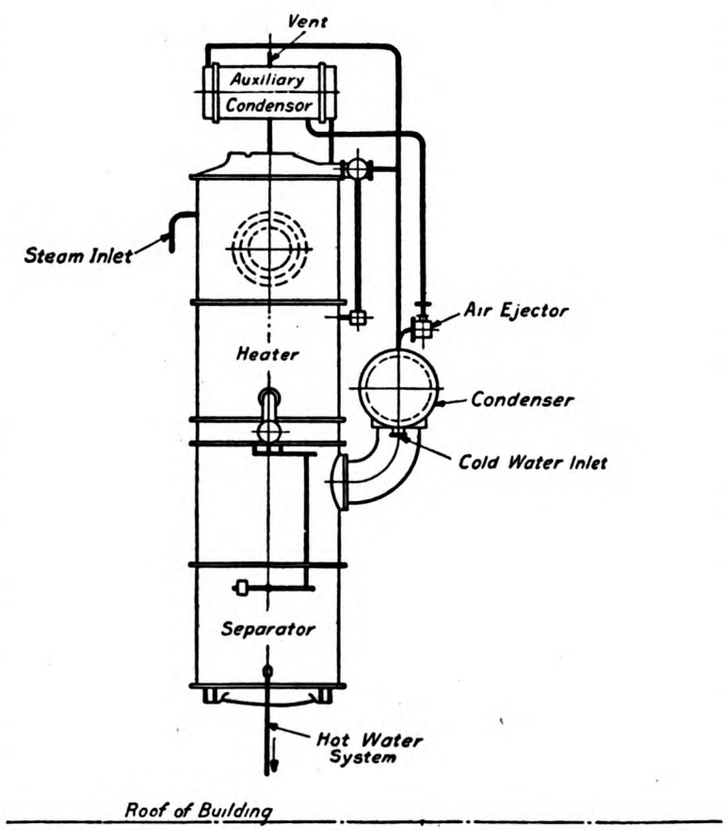


Fig. 11—Deaerator operating at reduced pressure.

Another type of mechanical deaerator has been designed and built by W. S. Elliott, one form of which for large buildings is illustrated (Fig. 11) which operates as follows: Raw water is taken from the supply line and conducted through the cooling circuit of the main surface condenser, which is designated in the diagram as "condenser." From the surface condenser the water passes to the heater, the flow of the greater

*Journal Am. Soc. H. and V. Engrs., March, 1921, p. 107.

Generated on 2024-09-08 15:49 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

portion of it being controlled by the inlet valve of the heater. A small portion of the water is by-passed to the heater through the cooling circuit of a small surface condenser, designated as an "auxiliary condenser," the function of which is to condense the steam used in the air ejector and recover the heat.

From the heater the water flows by gravity to the separator, the rate of flow being controlled by the inlet valve of the separator. In the separator, the air is removed by suddenly introducing the heated water into a region of vacuum in which the vapor pressure corresponding to the vacuum is lower than that corresponding to the temperature of the entering water. The water boils explosively, its temperature is lowered to the temperature of the vacuum and the dissolved gases separated. Some portion of the water is evaporated into steam in the separation process and the rest of it flows into the service pump line. The portion which has flashed into steam, mixed with the separated gases, is drawn into the surface condenser which is attached to the separator shell where the stream is condensed and the condensate returned to the separator; the heat of the stream is returned to the cooling water, and the non-condensable gases are removed by steam jet air ejector. From the separator, the hot deaerated water is delivered to the hot-water service line.

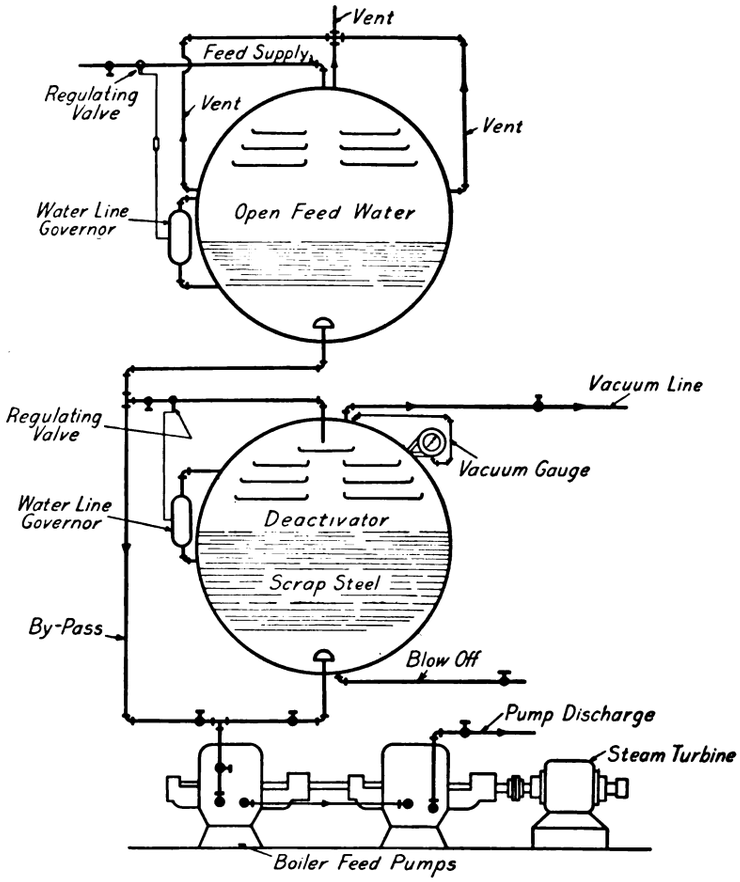


Fig. 12—Combined deaerator and deactivator for boiler feed water.

When correctly designed and operated at the proper rate, it is reported that very low oxygen contents can be obtained with this apparatus. It would seem that this form of deaerator is one that would be best adapted for larger power plant work, for instance where it is necessary to keep the oxygen contents of large quantities of feed water below 0.2 c.c. to preserve steel economizers. One has been installed quite recently in the Delaware plant of the Philadelphia Electric Company.

Deaeration of Cold Water.

Water at normal temperature usually has a comparatively low rate of corrosion and does no serious damage to galvanized pipes within 20 or 30 years, but there are exceptional locations where the cold water is more active or where the corrosion which does occur causes considerable inconvenience through clogging of the system with a bulky form of rust.

Then again cold salt water is more active than fresh water and causes considerable damage in the seaside hotels, bath houses, and in large condensing plants. Such corrosion can usually be reduced to a negligible amount by deaeration. The process of deactivation by steel scrap is usually too slow and therefore not economical for water at normal temperature, so that for such conditions we are forced to use a high vacuum aparatus. By reference to the diagram, Fig. 2, it will be seen that with a vacuum of 23 inches of mercury, about 80 per cent oxygen removal may be accomplished with water at 65 deg. F., which is as much as should be needed; in fact, a much lower percentage deaeration would, no doubt, suffice in most cases.

Incidentally it may be of interest to note that deaeration has been usefully applied to cyanide solutions used in the extraction of gold. In 1916 Thomas B. Crowe patented a "Process of, and Apparatus for, Precipitating Materials from Solution" (U. S. Patent Nos. 1,281,249 and 1,321,985), in which the essential element is the deaerating of the gold cyanide solution by means of a vacuum deaerator before the solution is treated with zinc for the precipitation of the gold. Removal of the dissolved oxygen from the solution prevents the formation of zinc oxide, which is said to save about 50 per cent of the zinc and cyanide formerly used. The Crowe Process, as it is now called, was first installed at the Portland Mill at Colorado Springs, Colo., but has since been put in use at other mills in the United States and abroad. The chemical reaction taking place in precipitating the gold may be represented as follows:

$$KAu(Cn)_2 + Zn + H_2O = Zn(Cn)_2 + Au + H + KOH$$

When dissolved oxygen is present, it has been found that zinc oxide is formed and that considerable excess KCn is required to completely precipitate the gold.

Deaeration for prevention of corrosion of a 30-inch steel main at a maximum temperature of 85 deg. F. has been successfully applied on a large scale in the Coolgardie Mining District, Western Australia.* This water, which is highly corrosive, is sprayed into a chamber under high vacuum. After operating for a few years, the results show that the deaerator extracts about 80 per cent of the dissolved oxygen and the cor-

*A description of this apparatus is found on pages 83 and 84 of a paper by O'Brien and Parr on "The Coolgardie Water Supply," Ins. of C. E., vol. 205, Session 1917-1918, Part I.

Generated on 2024-09-08 15:46 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

rosion activity is reduced by this means to about one-quarter of the original amount. The residual oxygen is removed after passing through about 30 miles of this pipe, after which the corrosion is reported to be negligible from observations made on steel test pieces. This water carries a small amount of magnesium chloride otherwise corrosion would, no doubt, be still further reduced by deaeration.

European Practice In Mechanical Deaeration.

Mr. G. Paris, in his paper on "Corrosion of Iron and Its Suppression by the Degasifying of Water,"* gives the most complete account which has yet been published of work which has been done on this problem in Europe, most of the practical end of which has been done during the past few years. He points out the drawback of degasification under high vacuum due to the difficulty of holding the vacuum in apparatus of a large size and that the minimum oxygen content is limited by the saturation point of water for any particular temperature and pressure. Evidently his experience has not been so favorable as we have found with apparatus of this class.

Several types of open feed water heaters, and deaerating apparatus, are described for extracting excess gas from water under pressure, with some new devices for separating gases mechanically from hot water under vacuum. The laws of solubility of gases in water indicate that to attain sufficiently low oxygen to prevent corrosion, the temperature should be at or near the boiling point for any particular pressure which in practice requires a prohibitive temperature, where the pressure is high, so that it has been found most economical to work deaerators at atmospheric pressure or lower.

The apparatus made by "Balke," of Bochum, Germany, for the extraction of gases from hot or cold water seems to have given good results. The water at normal temperature is violently sprayed into a chamber carrying a 90 per cent vacuum, the disengaged gases being drawn off by an air pump into a condenser. The following results have been published in Mr. G. Paris' paper (ibid):

	Amount of O_2 in cu. cent. per litre.		Amount of CO_2 in cu. cent. per litre.	
	Degasification			
	Before	After	Before	After
Installation of 50 cu. metres, 90 per cent. vacuum, average temp. 20 deg. C.	11.56	0	1.34	0
Installation of 50 cu. metres, 90 per cent. vacuum, average temp. 26 deg. C.	8.6	0.03	19.65	0

The Coolgardie deaerator operating with water at a maximum temperature of 85 deg. F. is reported to give over 80 per cent extraction of gas at high vacuum. The residual oxygen reported with the Balke apparatus operating cold seems altogether too low to be attained under conditions described.

The "Balke" apparatus for degasifying hot water, several of which are reported to have been built, consists of: A horizontal tank with transverse vertical partitions so arranged as to cause the water heated by steam in the first compartment to pass up and down through a circuitous course. The gases given off are collected by a manifold connected to the top of each compartment into a common main. It will be seen that this is practically an open type feed water heater. The treated water is passed into a closed tank where it is kept out of contact with air by an atmosphere of steam or nitrogen. The following results are reported operating at 100 deg. C. (ibid.):

Installations	Amount of O_2 in cu. cent. per litre.		Amount of CO_2 in cu. cent. per litre.	
	Degasification			
	Before	After	Before	After
Centrale Electrique de Treves.	10.50	0.22	1.13	0.00
Mine Adolphe	6.56	0.00	5.00	0.40
Westerwald	5.90	0.00	1.50	0.00

Combination of Mechanical and Chemical Deaeration.

It is obvious from the laws governing the solubility of gases in water and experience with deaerators built on this principle, that the percentage of oxygen removal possible is limited to the theoretical saturation point of oxygen in water at any particular temperature and pressure, whereas chemical deactivation when given sufficient time will go on at any temperature and pressure until all the available oxygen is exhausted. It would therefore seem that where very large volumes of water have to be completely deaerated, or nearly so, an economical type of apparatus would be one in which the bulk of the free oxygen, which is easy to remove, is extracted by some simple and economical form of deaerator and the residual oxygen, say the last 5 or 10 per cent, by chemical treatment. The latter may be accomplished by a few minutes' contact with a suitable form of sheet iron scrap or by reaction with ferrous hydrate from the addition of ferrous sulphate and lime. The action of ferrous hydrate is almost instantaneous but requires a reliable proportional feed of reagents. The combination of sheet iron deactivator with a preliminary deaeration has been employed in treating the hot water of one of the largest apartment houses of New York (Park Avenue and 48th Street). The water for the hot-water supply system is first put through a deaerator of the type shown in Fig. 9, located a little below the stand-pipe on the roof, and is then brought down to a steel deactivator in the basement before entering the system. This gives almost perfect protection to the hot-water pipes. Another design for a combination plant for power plant service is shown in Fig. 12* which includes an ordinary vented open type heater from which the water is passed into a tank at lower pressure but not so low as to boil the water, so that no condenser is required. The residual oxygen amounting to about 0.5 c.c. per litre is finally extracted by passing through steel scrap placed in the lower part of the vacuum tank. A vacuum control apparatus is attached.

Conclusion.

From this outline of the present status of corrosion prevention by deactivation and deaeration of water, the reader may gather some idea of the important application of these principles to the conservation of iron and other metals in closed systems—for what has been said of the protection afforded to iron applies equally well to brass and other metals which are subject to attack by water. As a rule, cold water does not seriously attack pipes or tanks in the life of a building or pipe line, but there are notable exceptions to this rule. The experience with the Coolgardie (West Australia) 30-inch pipe line and the satisfactory results of par-

Generated on 2024-09-08 16:12 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

TABLE I

Summary of Results of Investigations of the Corrosion of Wrought Iron and Steel Pipe in Hot Water Supply Service.

Time Removed	Where Test Was Made	Length of Time Pipe Lines Were in Service	Authority and References	Number of Cases on Record	Average of Deepest Pits, Inches: Wrought Iron	Average of Deepest Pits, Inches: Steel	Conclusions
1921	West 41st St. Public Baths, New York City.	4 yrs., 6 mos.	Charles Baskerville, Prof. of Chem., College of the City of N. Y. Reported June 22, 1921.	Fourteen sections of steel of three different makes, 6 sections of wrought iron pipe.	0.0592	Lot (1) .....0.0497 Lot (2) .....0.0535 Lot (3) .....0.0544 Average 0.0525	"Wrought iron showed deepest pitting. Appearance of corroded surfaces was characteristic — wrought iron showing isolated 'pits', steel, a more general corrosion with 'lakes' well distributed with more or less uniformity. The more uniform corrosion of the steel is a fact of no little importance."
1921	West 41st St. Public Baths, New York City.	10 years		Five sections of steel, one section of wrought iron pipe.	0.0606	0.0532	
1921	William Penn Hotel, Pittsburgh, Pa.	4 yrs., 7 mos.	Jas. O. Handy, Dir. Special Investigations Pgh., Testing Lab. Reported July 11, 1921.	Four sections each of wrought iron and steel pipe.	0.1095	0.094	"Such differences, which confirm previous tests, are conclusive as to the relative resistance to corrosion of steel and wrough iron pipe in hot water lines."
1919	Irene Kaufmann Settlement, Pittsburgh, Pa.	2 yrs., 7 days	James O. Handy, Technical Director, Pittsburgh Testing Laboratory. Report made to Resident Director Teller, Jan. 22, 1920; p. 97, Jan., 1920, A. S. H. & V. Engrs.; p. 276, Mar., 1920, A. S. H. & V. Engrs.	Fifteen lengths of steel, 15 lengths of wrought iron arranged alternately.	0.1144	0.1095	"These figures show that no marked distinction is possible between the rate of corrosion of the steel and the iron pipe."
1919	Harvard University Cambridge, Mass.	3 yrs.	Melville C. Whipple Prof. of San. Chem., Harvard University. Jrn'l New England Water Wks. Assn., p. 42, Mar., 1920.	Two sections each of scale-free (steel); galvanized steel, copper steel and wrought iron pipe.	0.073	Scale-Free 0.045 Copper Steel 0.068 Galvanized 0.078	"Judging from the depths of pitting and the general appearance of the inside of the pipe, it was evident that so far as the conditions of this particular experiment with the Cambridge hot water service were concerned, scale-free pipe had suffered less real damage than any of the others after three years' exposure."
1918	Brown University, Providence, R. I.	11 mos.	Wm. F. Kenerson, Professor of Mechanical Engineering, Brown University. Report made June 7, 1918. Bulletin 2 — "Corrosion of Hot Water Piping." National Tube Company.	Two sections each of black and copper steel and wrought iron; one section each of galvanized and copper steel, galvanized.	0.0674	Black Steel 0.0544 Copper Steel 0.0639 Galvanized 0.0547 Copper Steel Gal. 0.0938	"There is evidently no marked superiority of either the wrought iron or steel for the test conditions described. . . . The wrought iron failed first by developing the deepest pits. The steel developed a greater number of shallower ones."
	This test was conducted in four different places as follows:						
1917	(A) West 41st St. Bath, New York. (B) East 76th St. Bath, New York. (C) East 109th St. Bath, New York. (D) Cherry and Oliver Sts. Bath New York.	(A) 2 yrs., 9½ mos. (B) 2 yrs., 5 mos. (C) 2 yrs., 6 mos. (D) 2 yrs. 6 mos.	James S. Macgregor, Instructor in Civil Engineering, Columbia University. Report made Jan.-March, 1917. Bulletin 2 — "Corrosion of Hot Water Piping." National Tube Co.	(A) 3 sections each of wrought iron and steel pipe. (B) 4 sections of steel and 2 of wrought iron. (C) Same as test B. (D) One section each of steel and copper steel.	(A) 0.057 (B) 0.075 (C) 0.035	0.052 0.070 0.035 (D) Steel 0.021 Copper Steel 0.022	Taking the total averages of steel (which include scale-free and copper steel, as well as ordinary black) pipe as against those for iron in the four tests, we find the latter to have pitted deeper by 0.025 in. which indicates in favor of steel pipe in these particular tests.
1916	Irene Kaufmann Settlement, Pittsburgh, Pa.	10 mos.	Jas. O. Handy, Technical Director Pittsburgh Testing Laboratory. Report made October 31, 1916. p. 125, 1917 Trans. of A. S. H. & V. Engrs.	Seven sections of steel and 4 of wrought iron pipe.	0.116	0.110	The author states that a certain sample of wrought iron showed the most general corrosion, while a steel section showed the greatest number of seperate pits. No direct reference to comparative corrosion is made.

tial deaeration show that this method of protection can in some cases be economically applied to cold water when necessary. This would seem to apply particularly to cold as well as to hot salt water used in large seaside hotels, which cause considerable damage and costly repairs. While the laws underlying corrosion are now fairly well established, the economic application of these laws require a detailed knowledge of existing conditions interpreted in the light of previous experience as in all engineering developments. Much yet remains to be done in perfecting details, but the results already obtained are sufficient to indicate the permanent benefits to be derived through the application of these principles.

†Chemie et Industrie, July, 1921.

*Designed by the Anti-Corrosion Engineering Company, New York, U. S. A.

Generated on 2024-09-08 16:15 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

AMERICAN ENGINEERING STANDARDS COMMITTEE HANDLING 106 PROJECTS

The growing interest in standardization on the part of almost every American industry is emphasized by the quarterly report of the activities of the American Engineering Standards Committee issued from the headquarters of the Committee at 29 West 39th Street, New York City.

Of the projects which have official status before the A. E. S. C. 20 are concerned with mechanical engineering; 17 are civil engineering projects; 15 are electrical; three are automotive; 10 are concerned with transportation; 10 with ferrous metals; 11 with chemical; five with non-ferrous metals; four with mining; two with textiles; one with shipbuilding, and eight projects are of general interest.

Twenty-four standards or safety codes have been approved and 36 are up for approval. The remaining 4 projects represent codes and standards which are either in the process of formulation, or which are now being considered by committees of representatives, designated by the various bodies, industrial technical and governmental, interested in each particular subject. In this way, more than 200 such bodies are officially participating in the work of the A. E. S. C. through their accredited representatives.

A regular interchange of information as to the status of work under way is maintained by the American Engineering Standards Committee with the national standardizing bodies of Austria, Belgium, Canada, Czecho-Slovakia, France, Germany, Great Britain, Holland, Italy, Japan, Norway, Sweden and Switzerland. This information is issued in the form of quarterly reports and includes a statement of the status of each project on which work is actively under way.

POWER EXPOSITION TO BE CONDUCTED WITH CO-OPERATION OF ENGINEERS AND OPERATING MEN

The National Exposition of Power and Mechanical Engineering to be held at the Grand Central Palace in New York from Thursday, December 7 to December 13, closing, however, on the intervening Sunday, is being planned in co-operation with the national societies interested in the economy of fuel and in the production and use of power generated therefrom.

The opening of the exposition in the Grand Central Palace will take place on the closing day of the annual meeting of the American Society of Mechanical Engineers, and time has been set aside in the A. S. M. E. program so that members desiring may attend the opening exercises. Furthermore, the programs of the 20 sessions to be held at the A. S. M. E. meetings have been so arranged that all members attending the meeting may reap the advantage of the technical discussions, and with the smallest possible expenditure of time, enjoy the novel and varied exhibits at the exposition. A few of the subjects to be discussed at the A. S. M. E. meeting are:

Commercial Economy of High Pressures and High Superheats.
Feedwater Heating for High Thermal Efficiency.
Development and Use of Stokers.
Transmission of Superheated Steam.
Ash Removal—A Symposium of Modern Handling Methods.
Gears.
Power Required for Removing Metal.
Safety Valves.
Torsion of Crankshafts.
Pulsating Flow in Flow Meters.
Dry Vacuum Pump Tests.
Design of Flywheels.
Tests on Orifice Coefficients.
A Modern Works for the Production of Monel.
Metal Steam Table Research.

In addition, the A. S. M. E. Professional Divisions on Aeronautics, Ordnance, and Forests Products will hold sessions of general interest to the engineering profession.

The American Society of Refrigerating Engineers is to hold its meeting at the Hotel Astor for three days commencing December 5, and its members, as well as the members of the A. S. M. E. will be admitted to the exposition upon the presentation of their membership cards.

The opportunity this exposition offers for the power house operating man will also be grasped. The National Association of Stationary Engineers is perfecting plans for the various chapters to visit the exposition in a body. In addition, the New York Building Superintendents' Association, 600 strong, will attend in a body and they will be received by the officers of the N. A. S. E.

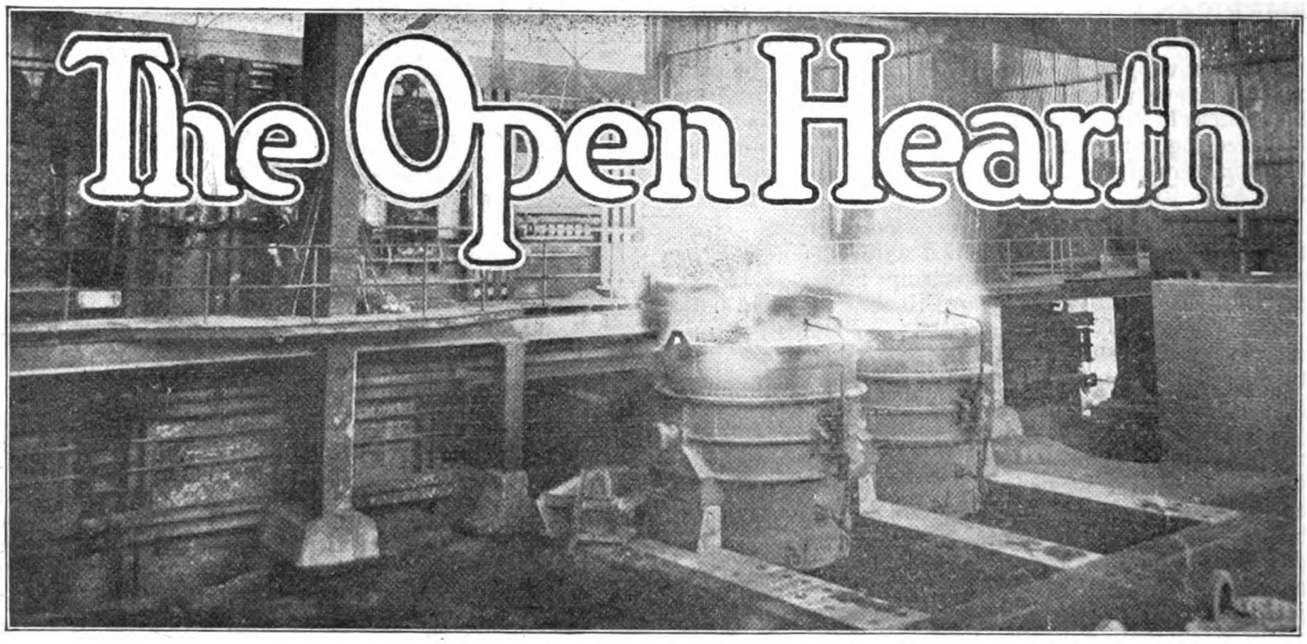
The list of exhibitors already assures the fact that the Grand Central Palace, with its remarkable facilities, will house the greatest exhibition of power plant equipment ever contemplated.

The exposition is fortunate in having an Advisory Committee that understands the importance of a greater popular appreciation of the engineering problems involved in the production and use of power. The committee is made up of Irving E. Moultrop, of the Edison Electric Illuminating Company of Boston, Chairman; Dexter S. Kimball, President of the American Society of Mechanical Engineers; Alexander G. Christie, Chairman Power Division A. S. M. E.; Fred Felderman, National President National Association of Stationary Engineers; Milan R. Bump, President National Electric Light Association; N. A. Carle, Vice-President Public Service Production Company of New Jersey; E. B. Katte, Chief Engineer Electric Traction N. Y. C. R. R. Company; Fred R. Low, Editor "Power"; David Moffat Myers, Consulting Engineer; Calvin W. Rice, Secretary The American Society of Mechanical Engineers; and the managers, Charles F. Roth and Fred W. Payne, with offices in Grand Central Palace.

STUDY OF ELECTRIC FURNACE REFRACTORIES

As it is hoped to develop refractories for electric furnaces ,it is desirable to have a method and apparatus for measuring their conductivity at advanced temperatures, states the Federal Bureau of Mines. Moreover, data in regard to the conductivity of existing refractories at temperatures above 1,400 deg. C. are meager. It is proposed by the bureau to study the leakage factor through refractories. The method of attack has been worked out and the furnace designed, the material for which is arriving at the bureau's ceramic experiment station at Columbus, Ohio.

Generated on 2024-09-08 16:07 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO



Samuel Wesley Stratton, organizer and for 21 years director of the Bureau of Standards, Washington, has resigned to become president of the Massachusetts Institute of Technology, January 1, 1923. He succeeds Dr. Ernest Fox Nichols, who never served as president, owing to illness, but who was elected to succeed the late Richard C. McLaurin.

V V

Julius Kahn, president of the Truscon Steel Company, Youngstown, Ohio, has returned from a three months' trip to Europe and is planning soon to leave to visit the companys' plant near Tokio, Japan.

V V

Walter S. McKee has resigned as vice president and director of the American Manganese Steel Company and will develop the business of the Inland Engineering Company of Chicago, of which he is president.

V V

J. B. Clark, Jr., has recently become associated with the Pennsylvania Crusher Company as sales engineer, and will make his headquarters at the company's New York office, Hudson Terminal, 50 Church Street. For a number of years Mr. Clark has been associated with the Koppers Company of Pittsburgh in the erection of by-product coke plants, including the Seaboard Plant at Jersey City. Mr. Clark will give particular attention to engineering co-operation in connection with the installation of the company's coal preparation machinery.

V V

John Aurelius, who retired recently as superintendent of the Farrell, Pa., plant of the American Steel & Wire Company, has become connected in an operating capacity with the Otis Steel Company, Cleveland.

V V

F. E. Clarke, electric furnace expert and secretary of the open hearth committee of the United States Steel Corporation for the past seven years, has resigned to become connected with the Sizer Steel Corporation, Buffalo, as general superintendent.

V V

David L. Eynon, president of the Pittsburgh Rolls Corporation, Pittsburgh, sailed on October 10 for a two months' European tour, during which he will visit the leading steel plants of England, France and Belgium.

V V

J. L. Mueller, formerly with the American Chain Company, York, Pa., has recently resigned to become vice president and secretary in charge of production with the International Chain & Mfg. Company, that city.

V V

D. I. Miller has been appointed manager of the B. Clow & Sons Company Coshocton, Ohio, plant. Mr. Miller was manager of the Grand River, Ky., plant of that company for several years. Mr. F. W. Schwab, who has been manager of both the Coshocton and Newcomerstown, Ohio, plants, will devote his entire time to the latter plant.

V V

George D. Cameron has tendered his resignation, effective January 1, as manager of the coal department of Pickands, Mather & Company, Cleveland, which he has held for a number of years.

V V

Jay L. Hench was recently appointed manager of sales, Hillside Fluor Spar Mines, Chicago, and is also to be vice president and member of the board of directors. Mr. Hench was formerly district sales manager of the Lackawanna Steel Company at Chicago.

V V

P. L. Coyle, formerly bar mill superintendent, Jones & Laughlin Steel Company, Pittsburgh, and later works manager, Electric Alloy Steel Company, Charleroi, Pa., has been appointed superintendent of bar mills, Witherow Steel Company, Neville Island, Pittsburgh.

V V

W. K. Strickland, recently with the General Motors research laboratory, has become affiliated with the Cadillac Motor Car Company, as assistant chief engineer.

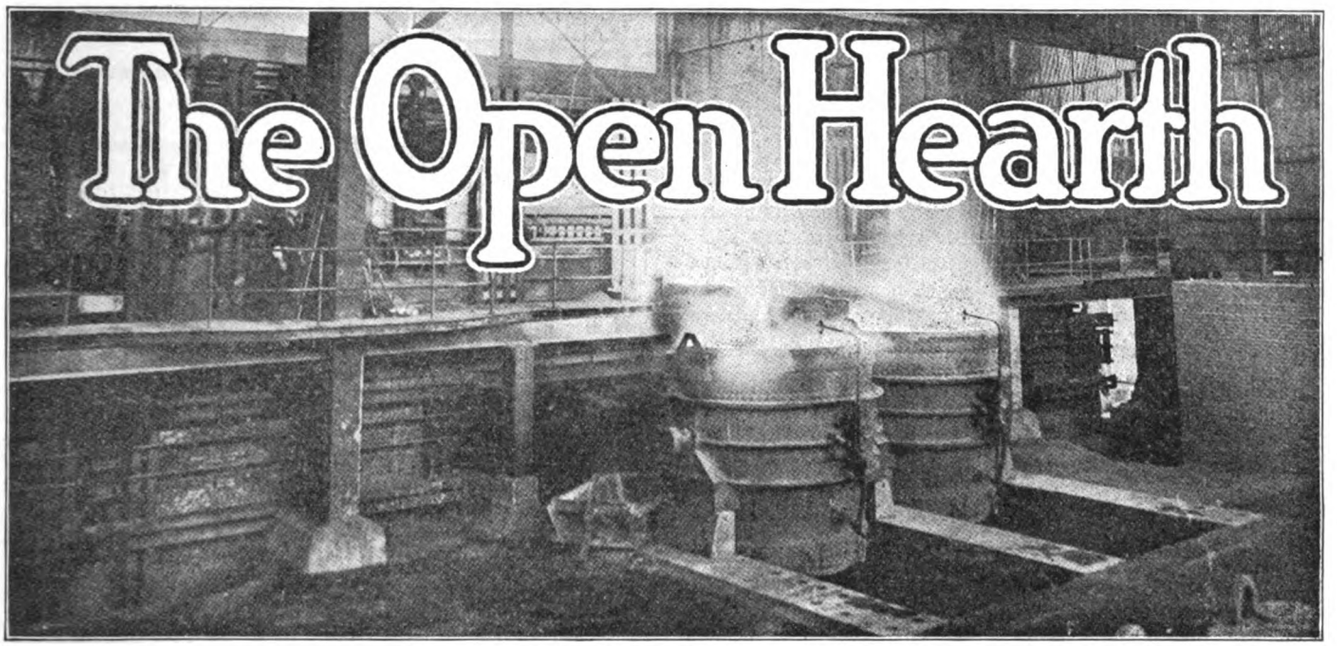
V V

James P. Davis, who has been chief of the shipping and order department, National Works, National Tube Company, McKeesport, Pa., has been transferred to the general order department of the company, Pittsburgh, as assistant to J. A. Caughey, chief of that department. Mr. Davis's successor at McKeesport is C. H. Starr.

V V

James A. Buell, formerly assistant general manager of the United Alloy Steel Corporation, Canton, Ohio, has resigned to become general superintendent of the Donner Steel Company, Buffalo, N. Y.

Generated on 2024-09-08 15:49 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO



D. Glynn Evans, metallurgist of the Llanelly Steel Company, Llanelly, Wales, manufacturers of sheet and tin bars, is visiting various iron and steel works in this country.

V V

Sherman A. Harding, who has been Pittsburgh district sales manager for the past three years for the Betts Machine Company, Rochester, N. Y., has been appointed manager of sales in that district for the Consolidated Machine Tool Corporation of which the Betts Machine Company became a constituent company in a merger effected a few months ago. Mr. Harding became affiliated with the Bridgeford Machine Tool Works in 1909 and was superintendent of that company when it was merged with the Betts Machine Company, following which he was made general superintendent of the latter company, holding that position for about two years before being made Pittsburgh district sales manager.

V V

Fred Gage has been named successor to John Aurelius, formerly superintendent of the company's Farrell, Pa., works, resigned. Mr. Gage was formerly assistant superintendent of the Donora, Pa., works. Charles Patt, also of the Donora works, has assumed the duties of assistant superintendent of the Farrell works made vacant by the death of John McHugh recently.

V V

W. H. Phillippi, vice president Lackawanna Bridge Works Corporation, a subsidiary of the Lackawanna Steel Company, and one of the properties recently taken over by the Bethlehem Steel Company, has resigned.

V V

Homer D. Williams, president Carnegie Steel Company, has been appointed member of the Pittsburgh Board of Public Education. The appointment is for six years. Mr. Williams is also a member of the State Council of Education and a trustee of the University of Pittsburgh and the Carnegie Institute of Technology.

V V

R. C. Kirk, who retired from the presidency of La Belle Iron Works, Steubenville, Ohio, at the formation of the Wheeling Steel Corporation, a little more than two years ago, has become affiliated with the Follansbee Brothers Company, Pittsburgh, having been elected vice president, treasurer and a director of that company. Mr. Kirk takes with him an experience of more than 25 years in the steel industry.

V V

A. L. Lee, who has been in the engineering department at the Ambridge, Pa., works, American Bridge Company, has been appointed resident engineer, United States Steel Products Company, at Bombay and Calcutta, India. He was tendered a farewell dinner and presented a gold watch by his former associates prior to his departure to his new post. Mr. Lee served overseas during the war, reaching the rank of major in the Engineer Corps.

V V

T. W. Harris, general foreman at the blast furnace of the St. Louis Coke & Chemical Company, Granite City, Ill., sailed from New York during the week of October 26 to become connected with the blast furnace staff of the India Iron & Steel Company at Asansol, Bengal, India. He expects to arrive in India in time for the blowing in of the first 500-ton furnace, which has been under construction in the past year.

V V

Charles P. McCrory, general manager, American Steel Company, Ellwood City, Pa., recently resigned to become president and general manager of the Liberty Steel Wire Products Company, Johnstown, Pa. Mr. McCrory has been in the steel and wire business for over 25 years, having held responsible positions with the Oliver & Roberts Wire Company, the American Steel & Wire Company and Jones & Laughlin Steel Company. He designed and built the American Steel Company plant at Ellwood City. The Liberty Steel Wire Products Company is building a new plant in Johnstown.

V V

John Calder, consulting engineer, Lexington, Mass., who has devoted the past three years to organizing and managing the industrial relations of Swift & Company, in its various plants in the United States and Canada, as central office in Chicago, will return to his practice in organization, management and industrial counsel on November 1. Mr. Calder has been appointed industrial adviser to Swift & Company.

V V

Edward T. Peterson was recently appointed chief engineer of the Birdsboro Steel Foundry Machine Company, Birdsboro, Pa. Mr. Peterson was formerly with the Treadwell Engineering Company, Easton, Pa.

Generated on 2024-09-08 15:49 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

NEWS OF THE PLANTS

The Baltimore Steel Company, Eastern Avenue and Eden Street, Baltimore, Md., has acquired property adjoining its plant, aggregating about 20,000 square feet of ground area, and will utilize as a site for the construction of an addition to its plant for considerable increase in production. The work will consist of a number of buildings, estimated to cost approximately $350,000, with machinery. Plans will be prepared in the near future.

The Nashville Bridge Company, Nashville, Tenn., has acquired property totaling about 12 acres of land at Bessemer, Ala., and has plans in preparation for the construction of a new steel fabricating plant, estimated to cost in excess of $90,000, including equipment.

The Wilmot Fleming Iron & Steel Company, 956 Foulkrod Street, Philadelphia, Pa., recently organized under state laws, has plans under way for the initial buildings for its proposed new one and two-story plant at Cottman and G Streets, for general steel and iron production. The plant will comprise a number of units, of which the first will cost approximately $75,000. It is expected to have the initial works ready for service at an early date. Wilmot Fleming is treasurer of the company.

The Weirton Steel Company, Weirton, W. Va., will commence the immediate erection of a new plant unit, aggregating about 110,000 square feet in floor area, consisting of eight complete sheet mills, to be devoted exclusively to the production of black and galvanized sheets. A site has been selected near the present stripping mill, with available land for future expansion. The new mills, with machinery, will cost about $1,500,000. A contract for the building erection has been let to the McClintic-Marshall Company, Pittsburgh, Pa. The company will also construct an addition to its open hearth department, consisting of three new furnaces, and increasing the output of this branch of the works from 700 to 1,000 tons per day. A by-product coke plant is also planned. The new extensions will give employment to more than 500 men. D. M. Weir, vice president of the company, is in charge of operations.

The Greenville Steel & Iron Company, Greenville, Pa., has plans out for bids for the construction of its proposed new plant on property recently acquired near the city limits. The works will consist of a number of buildings including one-story open hearth plant, 150x150 ft., with capacity of about 60 tons; one-story rolling mill, 150x500 ft.; power house and other miscellaneous works buildings. Other buildings will be constructed at a later date, forming a number of individual plant units, and bringing the investment to more than $3,000,000. A 500-ton blast furnace will also be built. The local Chamber of Commerce is interested in the project. Colonel H. P. Bope is president, and H. E. McConnell, managing director and consulting metallurgical engineer.

The Titusville Iron Works, South Franklin Street, Titusville, Pa., has plans under way for the construction of a new addition to its plant, for considerable increased capacity. It will be located on South Washington Street, one-story, and estimated to cost close to $100,000, with machinery and operating equipment.

The Wickwire-Spencer Steel Corporation, Webster Street, Worcester, Mass., has awarded a building contract to the E. D. Ward Company, Foster Street, Worcester, for the rebuilding of the portion of its mill at Spencer, near Worcester, recently destroyed by fire. The new structure will be three-story, 35x100 ft., and will cost approximately $60,000.

The Lockhart Iron & Steel Company, Pittsburgh, Pa., has perfected plans for the resumption of production at the plant of the Sligo Iron & Steel Company, Connellsville, Pa., recently acquired. The plant has been entirely reconstructed and improved, with the installation of considerable new equipment. It has a rated capacity of about 22,000 tons of muck bars a year, and will give employment to about 100 puddlers. Twenty puddling furnaces, with modern equipment and electric traveling crane, will be placed in service. The output of the plant will be used at the works of the Lockhart company at McKees Rocks, Pa., here to be converted into finished products.

In connection with its proposed expansion plans, the Armstrong Steel Company, Fort Worth, Texas, has acquired property at Houston, Texas, where it proposes to construct a new steel plant, estimated to cost in excess of $750,000. The works will consist of a number of buildings, including open hearth furnaces, equipped for a production of about 60,000 tons per year

The Casey-Hedges Company, Chattanooga, Tenn., manufacturer of steel plate products, has acquired local property for the construction of a new plant. It will consist of a number of buildings, devoted to the same line of present production, estimated to cost more than $100,000, including machinery. Plans will be prepared at an early date, and the project inaugurated.

The Flint Steel Company, Flint, Mich., lately organized, has taken over the plant and business of the Perkins Structural Steel Company, on local site, which has been in operation for about 12 months past. The new company contemplates a number of improvements and will operate the works at capacity. It is formed of officials of the previous organization, headed by W. L. Perkins as president and general manager.

The Atlas Steel Corporation, Dunkirk, N. Y., has been organized under state laws, with a capital of 1,000 shares of stock, no par value, to take over and consolidate the Atlas Crucible Steel Company, with local mills, and the Electric Alloy Steel Company, with plant at Charleroi, Pa. These two plants will be maintained in operation and expansion is contemplated. A branch works will also be operated at Welland, Ont. The combined assets of the consolidated company aggregate in excess of $10,000,000. Louis J. Campbell, heretofore president of the Electric Alloy Steel Company, will be one of the heads of the combined companies.

The Nagle Steel Company, Philadelphia, Pa., recently organized with a capital of $300,000, to take over and operate the plants of the company of the same name, has taken possession of the works at Pottstown, Seyfert, and Glasgow, Pa. Immediate operations are planned by the new owners; the plate mill at Pottstown will be run under full capacity, with double working shift. The Seyfert and Glasgow works will be improved and placed in service at an early date. The properties were acquired at a recent receiver's sale by George H. Heck, 518 Commercial Trust Bldg., Philadelphia, who will be one of the officials of the new organization.

Generated on 2024-09-08 15:55 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

Some Pointers on By-Product Coke Oven Operations

DISTRIBUTION OF SULPHUR FORMS IN COAL

During the fiscal year recently ended the investigation of the occurrence and distribution of the forms of sulphur in coal has been continued at Urbana, Ill., by the United States Bureau of Mines, in co-operation with the Illinois Geological Survey and the University of Illinois under two general heads, (1) The distribution of the forms of sulphur in the coal bed, and (2) Sulphur forms in coal. Both are closely co-ordinated with coal washing. The steadily decreasing reserves of low sulphur coal in certain sections renders it essential to have information on the occurrence and distribution of the forms of sulphur present in coals higher in sulphur; so that intelligent efforts may be directed toward reduction of sulphur and then utilization.

The distribution of the forms of sulphur in coal beds was investigated at two mines in Southern Illinois. A similar though less intensive investigation was made at a mine operating in the Pratt seam in Alabama. Since this work was done, one mine has materially reduced the sulphur content of both raw and washed coal by developing their lower sulphur forms.

The work on the sulphur forms occurring in coal is being conducted with the object of correlating the occurrence of sulphur forms with the washability of various coals with respect to sulphur reduction. During the year all the raw coal upon which washing tests were made and the washed products have been examined for the various forms of sulphur. It has been found that the organic sulphur content of a raw coal plus its content of finely disseminated pyrite sulphur fixes a limit below which no reduction in sulphur can be secured by ordinary coal washing methods.

FUSIBILITY OF COAL ASH

Data regarding the softening temperatures of coal ash from several hundred coals from the different fields of the country are contained in Bulletin 209, "Fusibility of Ash from Coals of the United States," by W. A. Selvig, assistant analytical chemist, and A. C. Fieldner, supervising chemist, just issued by the Bureau of Mines.

Information concerning the fusibility of coal ash has become of considerable value to the consumer of coal, mainly in connection with the troublesome formation of clinker resulting from the melting of the ash constituents of the burning coal. The growing interest in such data has led the Bureau of Mines to make a general survey of the "fusing" or "softening" temperatures of the ash from coals of the United States. It is hoped that this information, when used together with the large number of coal analyses published by the bureau, will assist the consumer of coal in comparing different coals, and in selecting the coal best adapted for his purpose.

Coal ash is the incombustible residue remaining after the complete combustion of coal; it is derived from the inorganic mineral constituents of the coal. The ash-forming constituents are (1) inherent or intrinsic impurities that are present in an inanimate mixture with the coal substance, and are derived either from the original material or from external sources such as sedimentation and precipitation while the coal forming plant remains accumulated; (2) impurities, formed either during the laying down of the coal bed or subsequently, that occur in the form of partings, veins, and nodules of clay, shale, "slate," pyrite, and calcite; and (3) impurities that become intimately mixed with the coal in the process of mining, such as fragments of roof and floor.

Coal ash is composed largely of compounds of silica, alumina, lime and iron, with smaller quantities of magnesia, titanium and alkali compounds.

Bulletin 209 may be obtained by addressing the Bureau of Mines, Washington, D. C.

DESULPHURIZATION OF COKE BY STEAM

A study of the action of steam on coke, with regard to the reduction in sulphur content of the coke, is being made at the Pittsburgh, Pa., experiment station of the Bureau of Mines by A. R. Powell, physical organic chemist, and S. H. Thompson, research fellow of the Carnegie Institute of Technology.

COAL PREPARATION

Problems that develop in the mechanical preparation of coal in the Central and Eastern coal fields are being investigated at the Central Experiment Station of the Bureau of Mines at Urbana, Ill., in co-operation with the University of Illinois and the Illinois Geological Survey. Work on coal cleaning methods is being continued, as the problem of cleaning coal is receiving more attention in the bituminous coal mining industry. A study has been made of the methods of examining a coal as it exists in the raw state, in order to determine the practicability of improving it by coal cleaning processes. The research is practically completed, and the methods developed for carrying out tests and interpreting the results are to be prepared for publication.

HEAT DISTILLATION OF COAL

J. D. Davis, fuels chemist, and Palmer B. Place, junior analytical chemist of the Pittsburgh, Pa., experimental station of the Bureau of Mines, have developed a precise method for the determination of the heat of reaction of coals during carbonization. Typical coals have been studied for reaction heats over ranges of temperature in which primary decomposition products are formed. The investigation is now being extended over higher temperature ranges where, according to theory, reaction heats should be largely endothermic.

USE OF STEAM IN COAL GAS RETORTS

The tendency toward lower standards of quality of gas in public utilities has increased the interest of the gas industry in processes that promise to increase the yield of gas per pound of coal coked, even though attended by a decrease in quality. The introduction of steam during or at the close of the coking process has shown considerable advantage in certain types of gas making installations, notably in vertical retorts. The Bureau of Mines, through W. A. Dunkley, gas engineer, has co-operated with the American Gas Association in studying the effects of using steam in horizontal retorts, which are commonly used. It was found that the method of admitting steam had much to do with the results obtained. Little, if any, water gas was generated by decomposition of steam in the retort charge, unless the contact between the steam and the chare was intimate. Steam as usually practiced in the small as plant, where the process has been tried , has no advantage. With prevailing standards of gas quality, little advantage can be taken of the use of steam, even if properly applied, as the production of any appreciable volume of water gas considerably reduced the general quality of the total gas production. Should standards be further reduced, the process might show more marked economies.

Generated on 2024-09-08 15:50 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

WITH THE EQUIPMENT MANUFACTURERS

NEW OPTICAL PYROMETER

The F. & F. Optical Pyrometer, according to its makers, The Scientific Materials Company of Pittsburgh, is particularly well adapted for many cases in which other types of pyrometers fail, especially:

When contact with the object, the temperature of which is to be measured, cannot be made; for example, rails passing through rolls, and other moving bodies.

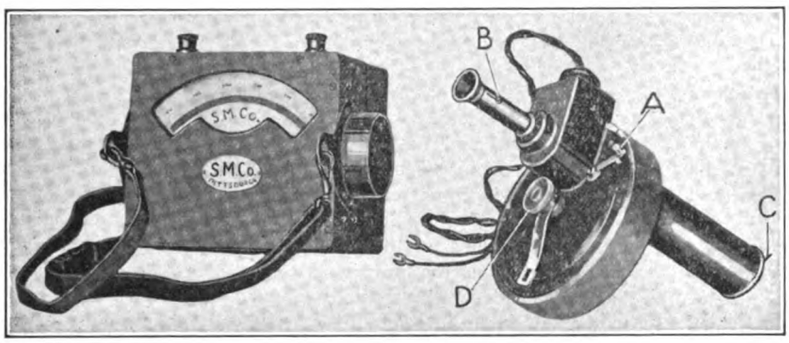


Fig. 1—F. & F. optical pyrometer. This pyrometer is but twelve inches in length and of light weight. It is convenient for using when contact with the object cannot be made.

When the pyrometer must be placed at a distance from the heated object; for example, a crucible or blast furnace.

When the temperature to be measured is above the range of thermo-couple pyrometers.

Its makers state that the operation of the instrument has been reduced to the greatest simplicity. Fig. 1 shows complete equipment. The pyrometer is small. being but 12 inches in length, and its light weight makes it convenient in handling. The metal parts are of aluminum with inserted brass and steel bearings. Both ocular and objective lenses are readily adjustable for focusing. The precision ammeter, battery and rheostat for making the normal setting are contained in a single, small, portable carrying case. The lever shown on the upper right hand side of the dial, throws in and out, the absorption glass for use with the extra scale for the high temperature range.

In making a temperature determination, the observer turns the rheostat on the battery box until the ammeter shows a certain specified reading—the "normal point." The pyrometer is then sighted on the furnace or object, the temperature of which is desired, and the knurled screwhead moving the wedge is turned until the tip of the filament disappears against the image of the source. The pointer indicates the temperature directly, no computing or reading of charts being required.

The calibration of the F. & F. pyrometer can be checked by the operator in practice, by sighting upon any known temperature. This is possible because the calibration curve of the wedge has been predetermined and always remains the same. Therefore, the correct temperature at which the lamp filament should be held is checked by sighting on a known temperature and adjusting the rheostat until the lamp filament disappears against the illuminated background.

The intensity at which the lamp burns is always kept constant. Its life is quite long as it burns at less than half of its rated capacity. This also increases the life of dry cells, as there is very small amount of current required to keep the lamp at its standard temperature.

ARMOR FRAME SINGLE ROLL COAL CRUSHER

The Pennsylvania Crusher Company, Stephen-Girard Bldg., Philadelphia, Pa., are placing on the market the Pennsylvania Armor Plate Single Roll Coal Crusher. They state that the substitution of the fabricated frame of steel plates in place of the more or less substantial cast iron frame which has been used in the past in their Bradford breaker and hammer crusher, warrants them in submitting this new design to those operating pulverized fuel plants.

The frame of the original single roll crusher, made at Hollidaysburg, Pa., naturally followed somewhat the line of double roll practice—the side frames being set on heavy timber foundations, without metal cross members, aside from the shafts. Later development provided heavy cast iron side frames and cross members. The direct drive of the roll shaft by means of a large flywheel pulley soon gave place to the powerful back geared drive through countershaft and smaller pulley. For heavy duty the frame was made in one massive box section casting, which later was sectionalized, particularly in the larger sizes.

The latest development, which marks a fundamental improvement in single roll design, provides a frame fabricated from slab steel plates into an unbreakable unit.

In the 18x18-in. and the 18x24-in. sizes, in which this design is now available, the steel side plates are 1-in. in thickness and

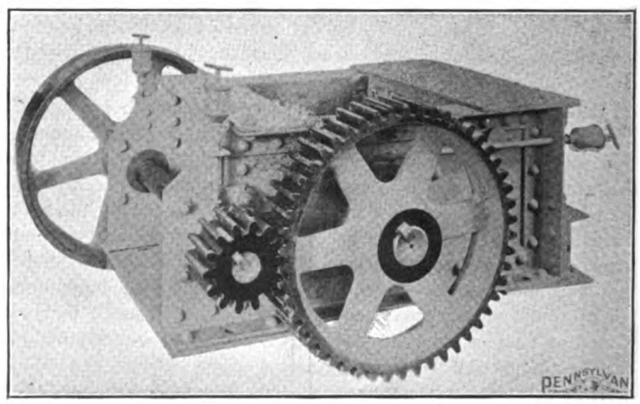


Fig. 1—Armor frame single roll coal crusher. The frame of this coal crusher is fabricated from slab steel plates in place of cast iron frames which have been used in the past.

are connected by nine steel cross members all heavily hot riveted into this rigid box frame.

Bronze bushed bearings are shouldered into the heavy side plates so that the bearing bolts are not subjected to shear.

The heavy flywheel pulley which drives the roll through heavy cut, back gearing, is provided with a shear pin safety device, mounting a steel bolt in hardened bushings, thereby insuring full

Generated on 2024-09-08 15:47 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

protection of the crusher parts against the accidental introduction of tramp iron with coal.

The breaker plate is a massive casting of high grade charcoal iron deeply chilled on the crushing surface. It is hinged in the frame at the upper end and suspended at the lower end by means of powerful relief springs. The breaker plate tip, which takes most of the wear, is a reversible and renewable manganese steel casting.

The segmental roll is cast from high grade charcoal iron, deeply chilled, or from chrome steel.

Convenient provision for adequate lubrication has been made by means of large steamboat type grease cups which can be screwed down without coming into close proximity with moving parts.

The crusher proportions are unusually liberal throughout, and the design insures a continuous supply of uniformly crushed coal by affording the three safeguards—unbreakable steel frame, steel shear pin safety device and powerful relief springs—as protection against the heavy tramp iron encountered in R. O. M. bituminous coal which often has proven destructive to crushing machinery.

NEW LINE OF SMALL VERTICAL BELT DRIVEN AIR COMPRESSORS

The Ingersoll-Rand Company, 11 Broadway, New York, announces a new line of small vertical belt driven air compressors known as Type Fifteen. In addition to the plain belt drive design each size is built as a self-contained electric motor outfit, driven through pinion and internal gears or by employing the short belt drive arrangement. The compressing end and electric motor of both gear and short belt drive units are furnished mounted on a common sub-base, so that they are in no way dependent upon the foundation for correct alignment.

Several noteworthy features of construction have been incorporated, of which the "Constant-Level" Lubrication System is the most important. Others include the Constant Speed Unloader for plain belt drive machines; the Centrifugal Unloader for start and stop control machines; and the increased size of the water reservoir cooling pot.

The lubrication of small vertical compressors employing the enclosed crank case and splash system has often been a source of concern wherever oil in the air is a serious menace. The tendency of the old system has been to feed too much resulting in discharged air containing excess oil, or too little causing scored cylinders, excess loads and burned out bearings.

The "Constant-Level" system used in Type Fifteen Compressors automatically maintains a constant-level of oil, which insures the right amount being distributed to all parts.

As with the ordinary splash system, the base of the compressor forms an oil reservoir for the "Constant-Level" system. However, with this system, pet cocks determine the maximum and minimum amount of oil in the reservoir. Above this reservoir and directly underneath the connecting rod is a constant-level pan. Oil is pumped from the reservoir into this constant-level pan through a unique oil pump. Regardless of the amount of oil in the reservoir, so long as it is somewhere between the high and low level pet cocks, this system will function perfectly, insuring a constant-level of oil in the pan. A projecting stem on the connecting rod dips into this pan and distributes just a sufficient quantity of oil for proper lubrication.

The Constant Speed Unloader controls the unloading of the compressor by automatically opening the inlet valve when the receiver pressure rises above that at which the unloader is set to operate. When the receiver pressure has fallen a predetermined amount, the unloader automatically releases the inlet valve and allows the compressor to return to work and thus build up the receiver pressure again.

The Centrifugal Unloader allows the compressor to start under "no load" such as is essential when automatic start and stop control is used, and permits the electric driving motor to come up to full speed before the load is thrown on automatically. This unloader accomplishes its purpose by holding the inlet valve open until the motor has reached full speed.

The smallest size is built with either ribbed cylinder for air cooling, where the service is intermittent, or a water jacketed cylinder of the reservoir type for contant service. All other sizes are only built with the water jacket of the reservoir type. The size of these reservoir pots is very generous, and one filling will be found sufficient for long periods of operation.

A NEW COMBINATION CRANE AND SHOVEL

One of the most modern combined utility machines for the contractor, supply yard, railroad or industrial plant is the improved crawling tread crane-shovel manufactured by the Orton & Steinbrenner Company of Chicago, Ill., and Huntington, Ind.

This company was one of the first to apply the continuous-tread principle to the propulsion of locomotive cranes. Being pioneers in the field they have utilized the experience gained through successive developments and improvements to the end that the present machine is the embodiment of all the better principles of design and construction. Two sizes of machines are manufactured—the ¾-yd. and the 1-yd. capacity.

The machine is more than a crane—more than a shovel. The design is such that in a minimum amount of time simply by removing the crane boom and substituting the shovel boom and dipper, the crane may be readily converted from a clam shell rig to a steam shovel. Even this is unnecessary to convert it into a skimmer for tearing up pavement. A separate boom with skimmer scoop can be connected to crane independent of the main crane boom and the hoist line simply reeved over the scoop.

The radius of the boom instead of being fixed at a certain degree, may be varied to suit the conditions of the job. This feature enables it to dig several feet below the normal operating level and also increases the lift.

Motive power is supplied by only two engines thus simplifying operations. The hoisting, swinging and travelling operations are performed with double clutches by the main non-reversing engines, while the crowding motion of the dipper is actuated by a separate reversing engine placed midway along the boom.

The rotating base turns on a live ring of rollers on a large diameter rail circle, thus evenly distributing the load and requiring very little power to swing.

The car body is built up of structural steel shapes and plates amply riveted and thoroughly reinforced.

The housing is of sheet steel with ample sash and doors and arranged for removal when required. The operator has a clear and unobstructed view of the dipper at all times.

The crawling tread is of the flexible type, adjusting itself automatically to the contour of the ground. The tread links are so designed that in passing around sprocket all foreign materials adhering to them are thrown off and prevented from entering the spaces between.

All movable parts are bronze bushed and lubricated with Alemite pressure system and sheaves and bearings are bronze bushed.

A feature of the machine is the accessibility of its parts, especially those bearing the brunt of the wear, consequently repairs when needed, can be installed in the field with a minimum amount of lost time.

Generated on 2024-09-08 15:55 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

TRADE PUBLICATIONS

Pyrometers — The Bristol Company, Waterbury, Conn., is distributing a new 68-page catalog devoted to Bristol Pyrometers. This catalog is profusely illustrated and contains very valuable condensed information on this subject.

Automatic Temperature Control and Signaling Instruments — The Brown Instrument Company is circulating their new catalog No. 85, on the automatic control of temperatures through Brown indicating and recording instruments.

Ferro Alloys and Metals — The Electro Metallurgical Sales Corporation, 30 West 42nd Street, New York, is distributing a beautifully printed catalog describing ferro alloys and metals manufactured by the Electro Metallurgical Company, which has works at Niagara Falls, N. Y.; Glen Ferris, W. Va., and Holcomb Rock, Va. It describes briefly the most important "Electromelt Brand" products and their uses in the field of ferrous and nonferrous metallurgy together with some historical statements which may prove of interest to those who have not closely followed the subject.

Liquid Fuel Burning for Generation of Steam—F. J. Ryan Company, Philadelphia, Pa., is circulating a bulletin on the burning of oil in connection with the generation of steam in which they take up at some length steam atomization burners, jet burners, steam mechanical burners and low pressure air burners, discussing the duty of the burner and the cost of operating.

Link Belt Catalog — The Link Belt Company, Chicago, Ill., announce the completion of a new general catalog which embraces their entire line. This catalog not only includes the complete Link Belt line but also the products of the H. H. Caldwell & Son Company. A brief summary of the contents covered follows: Link Belt chains, power transmission machinery, helicord and screw conveyors, conveyor equipment, boiler plant and coal tipple equipment, coal storage equipment, skips, etc., portable loaders, conveyors, locomotive and trolley type cranes, grab buckets, electric hoists and other special equipment.

Electric Furnaces — The Electric Company, Salem, Ohio, has recently published a six-page circular illustrating some of their many types of Bailey electric enameling, annealing and heat treating furnaces which they have installed in the last few years. They are also distributing a circular on melting furnaces which are used for the melting of nonferrous metals.

Blowers — Syracuse Industrial Gas Company, 208 S. Geddes Street, Syracuse, N. Y., is distributing a bulletin describing their uniform Multi-Stage Fan Type Blower, which is built in small capacities.

Air Conditioning — Reprint No. 729 from the Public Health Reprints of the Treasury Department of the U. S. Public Health Service is a paper prepared by C. E. A. Winslow, Professor of Public Health, Yale School of Medicine, on "Various Systems of Air Conditioning in a Munition Factory."

Coxe Stoker — The Combustion Engineering Corporation, Combustion Engineering Building, N. Y., have issued within the past month a bulletin covering the performance of this stoker on Western and Midwestern bituminous coal. A number of test charts each accompanied by corresponding curves are included. These tests show very remarkable results, and because they are complete in every respect will be of considerable interest to the engineering world. These stokers have proved successful in burning bituminous coal although three years ago it was thought to be impossible on draft, traveling grate stokers.

Elements of Industrial Heating — The W. S. Rockwell Company, Furnace Engineers, 50 Church Street, N. Y., is distributing a booklet prepared in an effort to give a proper view of the principals governing heat treatment of metallurgical, chemical and ceramic products, and the selection and use of equipment, fuel or electricity as a means to that end. They state that the matter is entirely technical and has been reviewed by teachers and engineers who have insured its accuracy and freedom from bias.

Steel Structure — McClintic Marshall Company, Pittsburgh, Pa., is distributing a book illustrating a number of buildings which they have erected in the past. This booklet is very beautifully bound and printed.

Furnace Chart Calculator — The Pittsburgh Electric Furnace Corporation, Pittsburgh, Pa., is distributing 'lectro calculator, which is a form of circular slide for calculating the additions of various alloys and metal mixtures to alloy in given percentage of alloy, and alloy in ordinary percentage of loss in the absorption of alloy. It is intended for the use of furnace superintendents and melters and the metallurgical profession in general; and will prove valuable in making calculations for the purposes intended.

TRADE NOTES

The Conveyors Corporation of America, 326 West Madison Street, Chicago, Ill., has appointed the George W. Fife Engineering Company, 1403 Merchants Bank Building, Indianapolis, Indiana, its representative for the sale of American Trolley Carrier in the State of Indiana. The American Trolley Carrier is equipment for handling coal from railroad cars to bunkers, silos or open storage pile. It consists of an overhead monorail, with a trolley from which a one-ton bottom dump bucket is suspended.

Westinghouse Krantz Works Moved to Mansfield.

Increased business necessitating increased production and more adequate facilities has resulted in the transfer of the Krantz works of the Westinghouse Electric & Manufacturing Company to Mansfield, O. The transfer of the Krantz works to Mansfield offers better facilities for increased production and gives the works a location in the central part of the country with easy access to a large number of railroads and to both the Middle West and Eastern offices of the Westinghouse Company.

Westinghouse Opens Sales and Service Building In Minneapolis.

In order to adequately serve the great territory known as the Twin-City area, the Westinghouse Electric & Manufacturing Company has leased a six-story building in the Minneapolis industrial district which will serve as a combined sales, service and warehouse center. The structure, which was built especially for and is leased by the Westinghouse Company for a period of 20 years, is one of a group of buildings included in the plan of the Northwestern Terminal Company of Minneapolis to provide an efficient and economical distributing service for the products of eastern manufacturers.

In order to promote the demand for corrugated metal roofing and siding protected with asbestos and asphalt, the Johns-Manvills, Inc., Pittsburgh, have been appointed joint selling agents by the H. H. Robertson Company, Pittsburgh. In the future all asbestos protected metal (more recently called Robertson Process Metal) roofing, siding, accessories and ventilators will be manufactured and shipped from the plant of H. H. Robertson Company at Ambridge, near Pittsburgh, Pa. Hereafter in the manufacture of Asbestos Protected Metal products by H. H. Robertson Company, the Johns-Manville asbestos saturated felts will be used.

COMING MEETINGS

December 7-13 — National Exposition of Power and Mechanical Engineering will be held at the Grand Central Palace with the exception of the intervening Sunday.

Generated on 2024-09-08 15:47 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO

Member of the Audit Bureau of Circulations.

Entered as second class mail matter at Pittsburgh, Pa., under the Act of Congress, March 3, 1879.

The Blast Furnace and Steel Plant

CHICAGO CRER. NOV 13 1922 LIBRARY.

Pittsburgh, November, 1922.

Generated on 2024-09-08 15:48 GMT / https://hdl.handle.net/2027/chi.096839170
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF CHICAGO